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ABSTRACT

This document contains the teacher and student texts and student workbook for a secondary-level course in shielded metal arc welding (SMAW) and carbon arc cutting that consists of units on the following topics: SMAW safety; SMAW equipment, applications, and techniques; hardfacing; and carbon arc cutting--air. The teacher edition includes the following items: (1) a training and competency profile for use in recording information about individual students; (2) a national skills and/or state duty/task crosswalk identifying skill standards covered by unit and objective; (3) an instruction/task analysis reviewing the cognitive and psychomotor skills addressed; (4) basic skills icons and classifications; (5) a basic skill matrix summarizing the academic and workplace skills training included in the course; (6) a list of needed tools, equipment and materials; (7) suggested activities; (8) assignment sheet answers; (9) written tests; (10) test answers; (11) teacher supplements; and (12) transparency masters. The student edition contains learning activities, objective and information sheets, and student supplements. The student workbook presents 37 job sheets accompanying the course's four units. Each job sheet contains some or all of the following items: objective; list of basic skills covered; instructions for completing the job sheet; list of required tools, equipment, and materials; detailed procedures; and specifications. (MN)

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ED 462 620

Shielded Metal Arc Welding and Carbon Arc Cutting—Air

Teacher Edition [and] Student Edition [and] Student Workbook

Third Edition

Eddie Harper and John Knapp

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Shielded Metal Arc Welding and Carbon Arc Cutting - Air

THIRD EDITION

MAVCC

Teacher Edition

BEST COPY AVAILABLE

Shielded Metal Arc Welding and Carbon Arc Cutting—Air

Teacher Edition

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Table of Contents

Introductory Pages

Foreword v
Acknowledgments vii
Use of this publication ix
Training and competency profile xvii
State of Oklahoma welding duty/task crosswalk xxi
Instructional/task analysis xxxi
Basic skills icons and classifications xxxv
Basic skills matrix xlix
Tools, equipment, and materials list ii

Units of Instruction

Unit 1: SMAW Safety

Unit 2: SMAW Equipment, Applications, and Techniques

Unit 3: Hardfacing

Unit 4: Carbon Arc Cutting—Air

Foreword

Shielded Metal Arc Welding and Carbon Arc Cutting—Air introduces students to "stick" welding. SMAW has been called the "essential" skill for welding because it introduces students to welding machines, welding electrodes, and the concept of fluxes and shielding which retain vital roles in other welding processes.

This third edition of *Shielded Metal Arc Welding* actually has a new name that reflects only a few of the enhancements that have been added. the new name is *Shielded Metal Arc Welding and Carbon Arc Cutting—Air*. As the new name implies, there is a new accent on Carbon Arc Cutting—Air. The process is now a full unit of its own with a special new job sheet on backgouging. What's more, hardfacing has been given a unit of its own and another new job sheet added to permit students to practice a real-world procedure. Special attention to safety matters are part of the Hardfacing unit.

These instructional materials have been designed to assist teachers in improving instruction. Every effort has been made to make these materials basic, readable, and usable. The teacher will need to develop instructional strategies for motivating their students, and localizing, individualizing, and supplementing the instructional materials. Suggestions for teaching the unit, suggested supplemental resources including Internet resources, a criterion-referenced test, teacher supplements, and transparency masters are included in the teacher pages for each unit of instruction.

This Third Edition of *Shielded Metal Arc Welding and Carbon Arc Cutting—Air* includes a Student Workbook that contains assignment sheets and job sheets for Units 2, 3, and 4. Student Workbooks can be purchased individually each year to help keep curriculum expenses at a minimum and still provide students with updated materials needed to complete the course.

MAVCC's complete welding series is crosswalked to the state of Oklahoma's Welding Duty/Task list which is aligned with AWS standards.

Kimberly Sadler, Chair
Board of Directors
Multistate Academic and
Vocational Curriculum
Consortium

Jane Huston
Executive Director
Multistate Academic and
Vocational Curriculum
Consortium

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Appreciation is extended to those individuals who contributed their time and talent to the third revision of *Shielded Metal Arc Welding and Carbon Arc Cutting—Air.*

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Thanks are also extended to Dan Fulkerson, Project Coordinator, and to Jane Huston, MAVCC Executive Director.

Use of This Publication

Shielded Metal Arc Welding and Carbon Arc Cutting—Air is available in both a teacher and student edition. The contents of these materials are tied to measurable and observable learning outcomes that were identified and validated by the welding advisory committee, comprised of business/industry representatives and teachers. Competencies align with the welding duty/task list developed by the state of Oklahoma.

Teacher Edition

The complete teacher edition consists of introductory pages and teacher pages. It is recommended that the instructor purchase the student edition and student workbook for a complete teacher edition. The introductory and teacher pages are loose-leaf and three-hole punched. The student edition is spiral-bound, and the student workbook is perfect-bound wit the pages perforated for easy removal. Each are divided into units of instruction that may be broken into more than one lesson or class period. For added flexibility, each unit in the teacher edition is individually numbered beginning with a T for teacher page, followed by the unit number and page number.

Example:

Page 17 of Unit 3 in the teacher pages are represented as T 3–17.

MAVCC—*Shielded Metal Arc Welding and Carbon Arc Cutting—Air*	T 3–17

Pages in the student workbook are numbered sequentially beginning with page 1.

MAVCC—Shielded Metal Arc Welding and Carbon Arc Cutting—Air	Page 1

Pages in the student edition are numbered beginning with the unit number, followed by the page number.

Example:

Page 7 of Unit 5 in the student edition is represented as Page 5–7.

MAVCC *Shielded Metal Arc Welding and Carbon Arc Cutting—Air*	Page 5—7

For group instruction, the teacher should determine the best way to teach each objective and allow for student participation. For self-paced or individualized instruction, students should be provided with opportunities to become involved in planning and being responsible for their own education. Careful study of each unit of instruction by the teacher will help to determine the following:

- amount of material that can be covered in each class period;
- supplies and materials required for assignment sheets and job sheets;
- resource people who must be contacted;
- supplementary materials to be ordered;
- skills that must be demonstrated and the amount of class time needed for demonstrations; and
- amount of class time needed for student practice and return demonstrations of mastered skills.

Teachers are encouraged to localize and personalize these materials to meet the needs of individual students, the community, and prospective employers.

Introductory Pages

In addition to general information, such as the table of contents, acknowledgments, and the use of this publication, the following tools have been provided to assist administrators and teachers in planning for instruction.

- **Training and Competency Profile.** This form may be copied and used to record information about each student, such as enrollment dates, class attendance, and work experience, and to document the student's mastery of specific job competencies. It can also be used to provide information about the student's qualifications to potential employers and/or for entry into advanced training programs.

- **National Skills and/or State Duty/Task Crosswalk.** This document identifies the national and/or state skill standards covered in this publication and lists specifically where these skills are located by unit number and objective.

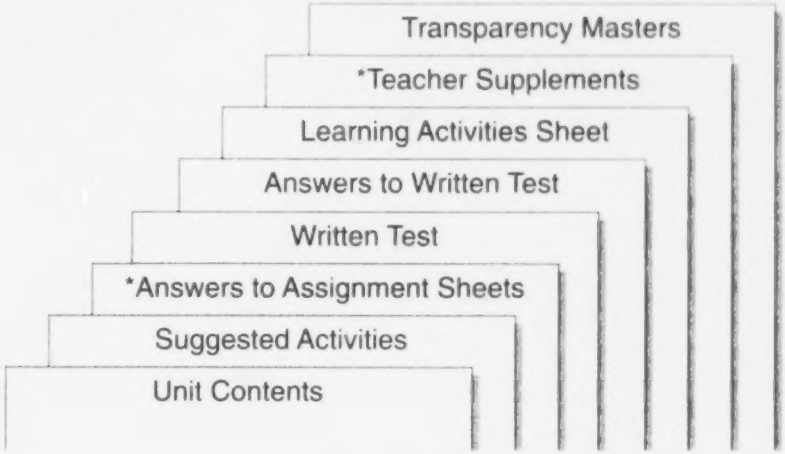
- **Instructional/Task Analysis.** This document provides a quick review of the contents of this publication by identifying the cognitive skills (what the student should know) and psychomotor skills (what the student should be able to do) addressed in each unit of instruction.

- **Basic Skills Icons and Classifications.** This page provides a reference guide of the graphic symbols that are used to identify the basic academic and workplace skills included in each focus assignment, assignment sheet, and job sheet.

- **Basic Skills Matrix.** This document graphically summarizes the academic and workplace skills training included in the instructional materials, unit by unit. It should be helpful to teachers in planning for instruction, and to administrators as documentation that basic skills are being taught as part of the vocational training.

- **Tools, Equipment, and Materials List.** This document provides a comprehensive list of those items needed in a vocational program for students to complete training. It also can assist administrators and teachers in determining program costs.

Teacher Pages



*Designates components that may not appear in every unit of instruction

Teachers should study the teacher and student pages before introducing the unit, allowing enough time to obtain supplemental materials and to contact outside resource persons.

- **Suggested Activities.** This component assists teachers during the preparation stage of the teaching/learning process by providing an instructional plan, teaching suggestions, a list of references used in the development of each unit, and a list of suggested supplemental resources (books, posters, pamphlets, videotapes, computer software, and Internet sites) that may be used to enhance instruction.

  Instructions for evaluating student performance on the assignment sheets and job sheets are also included in the suggested activities section. Teachers should select and discuss with students the rating scale that will be used.

- **Answers to Assignment Sheets.** An answer key is provided, when applicable, to assist the teacher in evaluating student performance on a given assignment.

- **Written Test.** This component provides criterion-referenced evaluation of every cognitive objective listed in the unit of instruction, and serves as both a pretest and posttest to assist teachers in measuring each student's competency gains. (Assignment sheet and job sheet objectives are not evaluated on the written test.) If the teacher has added, deleted, or modified any objectives, appropriate changes should be made to both the test and answers to the written test.

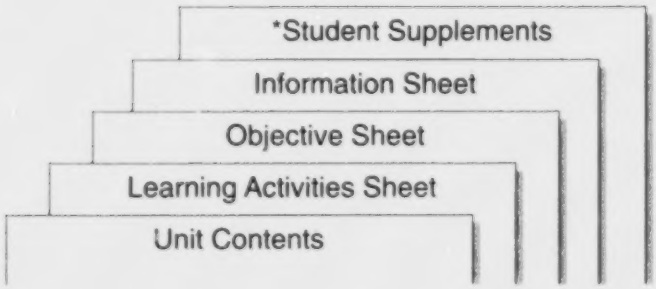
Tests may be divided into shorter tests covering three or four objectives at a time and given soon after those objectives have been covered. A selection of test items from the units covered may be used for a final test at the end of each term if desired. The written test is included in the teacher edition only and should be duplicated for student use.

- **Answers to Written Test.** An answer key is provided to assist the teacher in evaluating student performance on the written test.

- **Teacher Supplements.** These are optional materials for the teacher to use. They have three purposes: to provide the teacher with higher-level materials to stretch the advanced student; with remedial information or practice to assist the less-advanced student; and with state-of-the-art information in which the teacher may not have a background or with information that is not readily available in other books. Some teacher supplements may be duplicated for student use and are marked accordingly.

- **Transparency Masters.** These overheads are used to direct the students' attention to the topic of classroom discussion. Transparencies allow the student to see as well as hear the information being presented, thus reinforcing the learning process. They may provide illustrations, charts, schematics, or additional information needed to clarify and reinforce objectives included in the unit of instruction. Some of these items may also appear with the appropriate objectives in the information sheet in the student edition. The teacher may make acetate copies from the masters or, in most cases, complete transparency sets are available for purchase.

Student Edition



*Designates components that may not appear in every unit of instruction

For best results, students should be provided with a copy of the student edition and should be allowed to take notes in the margins as additional information is provided by the instructor or as the student acquires additional information through library or Internet research.

- **Learning Activities Sheet.** This component provides a model for teachers to use in implementing a self-paced or individualized program, and guides the student through the required components in the student edition (objective sheet, information sheet, student supplements, assignment sheets, and job sheets). The teacher should modify the learning steps as needed to incorporate resources available in the classroom (videotapes, computer software, magazines, etc.) and to address instructional strategies that may be needed to enhance learning for each student. Final copies should be distributed for student use.

  The following icons will be used on the learning activities sheet to denote steps that require additional resources:

  Read a book, magazine, or journal article

  Use a CBT program or other software application

  Access a site on the World Wide Web

  Look at PowerPoint® or other computer presentation

  Watch a videotape

- **Objective Sheet.** This component summarizes each unit for the student and teacher. The objective sheet is based on established performance objectives that state the goals for successful completion of a unit of instruction. Objectives are stated in two forms: unit objectives that state the expected performance of each student after completion of the unit and specific (enabling) objectives that state what the student must be able to do to reach the unit objective.

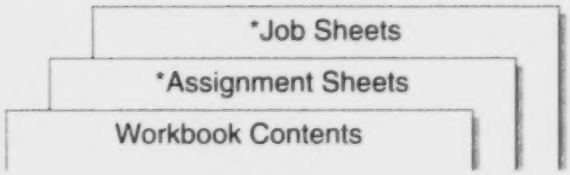
  The objectives should be stressed throughout the teaching/learning process. This will help answer any questions concerning performance requirements for each instructional unit. The objectives can also help determine teaching strategies and instructional methods.

Teachers should modify, delete, or add objectives in order to meet the needs of the students and community. When objectives are added, the teacher should remember to supply the needed information, assignment and/or job sheets, and criterion-referenced test items to cover the new objectives.

- **Information Sheet.** This component provides the student with the essential information for meeting the cognitive objectives in the unit. Teachers will find that the information sheet serves as an excellent guide for presenting background knowledge necessary to develop the skills specified in the unit objective. Students should read the information sheet before the information is discussed in class. Space is provided in the margins for students and teachers to add notes that clarify and/or expand upon the information presented.

- **Student Supplements.** This component is included in a unit of instruction when additional information is needed in order for students to complete one or more of the assignment and/or job sheets. Students are not directly tested over the information presented in a supplement; however, their ability to apply this information may be evaluated in the completion of assignment and/or job sheets.

Student Workbook



*Designates components that may not appear in every unit of instruction

The student workbook is an integral part of the student materials and should be provided to each student. It contains the pen-and-paper exercises and skill tests necessary for student mastery of the course.

- **Assignment Sheets.** The assignment sheets address the learning levels at or above the application level of Bloom's taxonomy. They provide students with an opportunity to use higher-order thinking skills, such as problem solving, synthesizing, analyzing, and evaluating. In addition, they may provide additional opportunities for students to develop their language skills.

  Assignment sheets can be paper-and-pencil activities, as well as those using computer software, videotapes, models, handouts, or other resources as appropriate. Criteria are provided to evaluate student performance objectively.

- **Job Sheets.** Job sheets are designed as skill tests and give the instructor direction as to the psychomotor skills to be taught, and provide the criteria to evaluate student performance objectively. They also help provide potential employers with a picture of the skills being taught during training and the performances that might be reasonably expected from an individual who has completed the training.

  The teacher should provide students with a copy of each job sheet and/or the procedure's manual and/or job specifications when necessary. The teacher should also discuss the equipment and materials that will be needed for the job and the criteria that will be used to evaluate the student's performance, and demonstrate the procedure prior to having students practice the procedure. Safety should be stressed as part of each demonstration.

  When a student is ready to be evaluated, the teacher should follow the instructions for evaluating student performance which may be found in the suggested activities component of the teacher unit.

- **Glossary.** This optional item is a compilation of the terms and definitions included in each unit of instruction and terms are presented in alphabetical order.

As you use these instructional materials we hope that you will find that they contribute to the quality of your program. If any problems occur or if you have any suggestions for improvement of the materials, please write us at 1500 West Seventh Avenue, Stillwater, OK 74074-4364, or e-mail us at mavcc@mavcc.com.

Training and Competency Profile

Student Information

Program _____ Instructor _____

Name _____ Soc. Sec. No. _____

Address _____ Phone _____

Grade _____ School _____

Allergies/Disabilities that might require special accommodation for training (please specify)

_____

In case of emergency, contact _____ Phone _____

Record of Enrollment

Date of Enrollment ____- ____- ____ Total Class Hours_____ Total Hours Absent_____

Date of Withdrawal ____- ____- ____ Total On-the-Job Training Hours_____ Total Hours Tardy_____

Date of Completion ____- ____- ____ Total Lab Hours_____

On-the-Job Training/Work Experience

_____ _____
Place of Employment Address

_____ _____
Supervisor's Name Phone

_____ _____
Duration of Employment Job Title

_____
Job Responsibilities

_____ _____
Place of Employment Address

_____ _____
Supervisor's Name Phone

_____ _____
Duration of Employment Job Title

_____
Job Responsibilities

Training and Competency Profile

Student Evaluation

Directions: Evaluate the student using the rating scale below. Write the appropriate number to indicate the degree of competency achieved. The descriptions associated with each of the numbers focuses on a level of student performance for each of the tasks listed. The written test scoreline is provided for optional teacher use. It may not be applicable in all cases.

Rating Scale: Option A

4 Skilled—Can perform job with no additional training
3 Moderately Skilled—Has performed job during training program; limited additional training may be required.
2 Limited Skill—Has performed job during training program; additional training is required to develop skill.
1 Unskilled—Is familiar with process, but is unable to perform job.
0 No Exposure—No information or practice provided during training program, complete training required.
NA Non-applicable.

Rating Scale: Option B

Yes—Can perform with no additional training
No—Is unable to perform satisfactorily

Unit 1: SMAW Safety

_____ 1. Solve problems concerning SMAW Safety.
_____ 2. _____
_____ Written Test Score

Unit 2: SMAW Equipment, Applications, and Techniques

_____ 1. Start and restart an arc, crater, and backfill at the edge while running a bead on mild steel plate.
_____ 2. Build a pad on mild steel plate in the flat position with an E6010 electrode.
_____ 3. Build a pad on mild steel plate in the flat position with an E7018 electrode.
_____ 4. Weld to specifications a fillet weld lap joint in the flat position with an E6010 electrode.
_____ 5. Weld to specifications a multipass fillet weld on a T-joint in the flat position with an E6010 electrode.
_____ 6. Weld to specifications a fillet weld lap joint in the flat position with an E7018 electrode.
_____ 7. Weld to specifications a multipass fillet weld on a T-joint in the flat position with an E7018 electrode.
_____ 8. Weld to specifications a fillet weld lap joint in the flat position with an E7024 electrode.
_____ 9. Weld to specifications a multipass fillet weld on a T-joint in the flat position with an E7024 electrode.
_____ 10. Weld to specifications a fillet weld lap joint in the horizontal position with an E6010 electrode.
_____ 11. Weld to specifications a multipass fillet weld on a T-joint in the horizontal position with an E6010 electrode.
_____ 12. Weld to specifications a fillet weld lap joint in the horizontal position with an E7018 electrode.
_____ 13. Weld to specifications a multipass fillet weld on a T-joint in the horizontal position with an E7018 electrode.
_____ 14. Weld to specifications a fillet weld lap joint in the horizontal position with an E7024 electrode.
_____ 15. Weld to specifications a multipass fillet weld on a T-joint in the horizontal positions with an E7024 electrode.
_____ 16. Weld to specifications a fillet weld lap joint in the vertical position with an E6010 electrode.
_____ 17. Weld to specifications a multipass fillet weld on a T-joint in the vertical position with an E6010 electrode.
_____ 18. Weld to specifications a fillet weld lap joint in the vertical position with an E7018 electrode.
_____ 19. Weld to specifications a multipass fillet weld on a T-joint in the vertical position with an E7018 electrode.
_____ 20. Weld to specifications a fillet weld lap joint in the overhead position with an E6010 electrode.
_____ 21. Weld to specifications a multipass fillet weld on a T-joint in the overhead positions with an E6010 electrode.
_____ 22. Weld to specifications a fillet weld lap joint in the overhead position with an E7018 electrode.
_____ 23. Weld to specifications a multipass fillet weld on a T-joint in the overhead position with an E7018 electrode.
_____ 24. Weld to specifications a V-groove butt joint in the flat position with an E6010 electrode.
_____ 25. Bend test a welded V-groove joint.
_____ 26. Weld to specifications a V-groove butt joint in the horizontal position with and E6010 electrode.
_____ 27. Weld to specifications a V-groove butt joint in the vertical position with an E6010 electrode.
_____ 28. Weld to specifications a V-groove butt joint in the overhead position with an E6010 electrode.

_____ 29. Weld to specifications a V-groove butt joint in the flat position with an E6010 electrode root and an E7018 fill and cap.

_____ 30. Weld to specifications a V-groove butt joint in the horizontal position with an E6010 electrode root and an E7018 fill and cap.

_____ 31. Weld to specifications a V-groove butt joint in the vertical position with an E6010 electrode and an E7018 fill and cap.

_____ 32 Weld to specifications a V-groove butt joint in the overhead position with an E6010 electrode root and an E7018 fill and cap.

_____ 33. _____

_____ Written Test Score

Unit 3: Hardfacing

_____ 1. Build a pad on mild steel with a hardfacing electrode.

_____ 2. Prepare and hardface simulated bucket teeth.

_____ 3. _____

_____ Written Test Score

Unit 4: Carbon Arc Cutting—Air

_____ 1. Gouge a piece of mild steel with the air carbon arc cutting process.

_____ 2. Backgouge a V-groove butt joint to prepare for complete fusion of the weld joint.

_____ 3. _____

_____ Written Test Score

State of Oklahoma Welding Duty/Task Crosswalk

The following state of Oklahoma welding tasks, which are aligned to AWS standards, are covered in this publication. The first column identifies Oklahoma's task by name and number. The second column identifies the exact location by unit number and objective, assignment sheet, or job sheet in this MAVCC publication unless otherwise noted.

Occupation: Shielded Metal Arc Welder	MAVCC Tasks
Duty A: Demonstrate Employability Skills	
A.18 Identify employment opportunities	*Fundamentals of Welding*, Unit 1, Objective 7—Job outlook for welders; Objective 9—Career opportunities for welders; Assignment Sheet 2—Compare employment opportunities in welding
A.19 Identify levels of training recommended for related careers	*Fundamentals of Welding*, Unit 1, Objective 8—What it takes to become a good welder
A.20 Understand salary, wages and benefits packages	*Fundamentals of Welding*, Unit 1, Objective 6—What welders earn
Safety	
A.26 Explain the purpose for safety policies	*Fundamentals of Welding*, Unit 2, Objective 4—Hazard communication; Assignment Sheet 1—Complete the student safety pledge form; Assignment Sheet 5—Identify and correct safety violations
A.27 Discuss the role of OSHA and EPA — Locate information in MSDS	*Fundamentals of Welding*, Unit 2, Objective 6—Purposes of material safety data sheets; Student Supplement 1—Guidelines for interpreting material safety data sheets; Assignment Sheet 2—Interpret a material safety data sheet
A.28 Participate in OSHA training, if possible — Lock Out/Tag Out	*Fundamentals of Welding*, Unit 2, Objective 8—Safety tags and their color coding; Objective 19—Instances when lockout devices should be used
— HAZCOM	*Fundamentals of Welding*, Unit 2, Objective 4—Hazard communication
— MSDS	*Fundamentals of Welding*, Unit 2, Objective 6—Purposes of MSDS; Student Supplement 1—Guidelines for interpreting MSDS; Assignment Sheet 2—Interpret a material safety data sheet

Occupation: Shielded Metal Arc Welder	MAVCC Tasks
— Bloodborne Pathogens	*Fundamentals of Welding*, Unit 3, Objective 18—Basic first-aid procedures for various emergency situations
A.29 Explain the proper steps in reporting an accident or emergency	*Fundamentals of Welding*, Unit 3, Objective 16—General steps for handling any emergency situation; Objective 17—General guidelines for first aid emergencies; Assignment Sheet 1—Determine basic first aid measures for given emergency situations
A.30 Explain the hazards associated with specific types of equipment and tools	*Fundamentals of Welding*, Unit 2, Objective 3—General job and shop safety rules; Assignment Sheet 5—Identify and correct safety violations *GMAW/FCAW*, Unit 1, Objective 10—Rules for handling hollow casting or containers; Objective 11—Hazards associated with arc rays
A.31 Perform machine operator safety checks of equipment and accessories, when necessary	*Fundamentals of Welding*, Unit 2, Assignment Sheet 5—Identify and correct safety violations; Unit 4, Objective 21—Basic rules for safe use of power tools and equipment
A.32 Practice tool safety	*Fundamentals of Welding*, Unit 2, Objective 3d—Tool use, maintenance, and storage safety; Unit 3, Objective 9—Rules for handling welding cables and gas and coolant hoses; Unit 4, Objective 20—Rules for hand tool safety; Objective 21—Basic rules for safe use of power tools and equipment; Objective 22—Rules for tool and equipment maintenance
A.33 Describe the types of fire hazards found in the workplace	*Fundamentals of Welding*, Unit 2, Objective 10—Components of fire triangle; Objective 11—Types of fires and classifications; Objective 12—Types of fire extinguishers; Objective 13—Fire extinguisher markings and class of fire they represent; Objective 14—Fire extinguisher operating instructions that follow P-A-S-S; Student Supplement 2—Using Portable Fire Extinguishers; Assignment Sheet 4—Determine correct fire extinguishers to use for various situations; Job Sheet 1—Operate a fire extinguisher

Occupation: Shielded Metal Arc Welder	MAVCC Tasks
A.34 Discuss electrical hazards	*Fundamentals of Welding*, Unit 2, Objective 3f—Electrical safety; Unit 3, Objective 19—Treating a victim of electrical shock *GMAW and FCAW*, Unit 1, Objective 7—Electrical safety requirements for GMAW
A.35 Demonstrate safe use of personal protective equipment	*Fundamentals of Welding*, Unit 2, Objective 20—Fall protection systems; Objective 21—Confined space entry; Objective 22—Environmental contaminants that would require you to use a respirator *GMAW and FCAW*—Unit 1, Objective 12—Types of welding hoods; Objective 13—Guidelines for selecting a safe lens shade for GMAW; Objective 14—Protective clothing required for GMAW welding; Objective 15—Environmental safety requirements; Objective 16—Safety guidelines for working with electrode wire
A.36 Demonstrate safe material handling techniques — Lifting — Transporting — Storing	*Fundamentals of Welding*, Unit 2, Objective 15—Causes of back injuries; Objective 16—Guidelines for lifting and moving items safely; Job Sheet 2—Lift a heavy object properly
A.37 Understand established first aid procedures	*Fundamentals of Welding*, Unit 3, Objective 16—General steps for handling any emergency situation; Objective 17—General guidelines for first aid emergencies; Objective 18—Basic first-aid procedures for various emergency situations; Student Supplement 2—A systematic look at first aid; Assignment Sheet 1—Determine basic first aid measures for given emergency situations
A.38 Practice good housekeeping	GMAW and FCAW—All job sheets require students to clean up their work areas and return tools and equipment to proper storage.
A.39 Comply with company safety policies	*Fundamentals of Welding*, Unit 2. Assignment Sheet 1—Complete the student safety pledge form

Crosswalk

Occupation: Shielded Metal Arc Welder	MAVCC Tasks
Basic Academic Skills	
A.40 Apply mathematical operations involving whole numbers, fractions, decimals, percentages; mathematical word problems, ratios, etc., when necessary — Addition — Subtraction — Multiplication — Division	*Fundamentals of Welding*, Unit 6, Assignment Sheet 1—Add, subtract, multiply, and divide fractions; Assignment Sheet 2—Add, subtract, multiply, and divide decimal equivalents; Assignment Sheet 3—Convert fractions to decimal form, change fractions to a common denominator, and reduce fractions to lowest terms; Assignment Sheet 4—Write fractions as decimals and percents; Assignment Sheet 6—Write decimals as fractions and percents; Assignment Sheet 8—Make conversions with an inches-to-decimal conversation chart.
A.41 Apply advanced mathematical operations, when necessary — Algebra — Geometry — Trigonometry — Calculus — Statistical Methods	*Fundamentals of Welding*, Unit 6, Objective 8—Terms used in geometry; Objective 9—Types of geometric figures; Objective 12—Area of geometric figures; Assignment Sheet 14—Calculate area of geometric figures; Job Sheet 1—Adjust a bevel square to a 45° angle using a framing square, a combination square, and a protractor; Job Sheet 2—Form 90° and 45° angles with a combination square and draw parallel lines on metal stock
A.42 Apply scientific principles, when necessary — Physics — Chemistry	*Fundamentals of Welding*, Unit 5, Objective 4—Metal identification tests; Objective 5—Mechanical properties of metals; Objective 6—Types of mechanical strengths, Objective 7—Physical property of metals; Job Sheet 1—Conduct magnet tests to identify common metals used in welding; Job Sheet 2—Conduct chisel test to identify common metals used for welding; Job Sheet 3—Conduct spark tests to identify common metals used for welding
A.43 Interpret charts, table, and graphs	*Fundamentals of Welding*, Unit 6, Assignment Sheet 7—Make conversions decimals with a decimal equivalent chart; Assignment Sheet 8—Make conversations with an inches-to-decimal conversion chart
A.44 Apply reading and writing skills, when necessary	Most assignment sheets require the student to read and write.

Occupation: Shielded Metal Arc Welder	MAVCC Tasks
Blueprint Reading	
A.50 Identify basic elements of blueprints — Terms — Components — Symbols	*Fundamentals of Welding*, Unit 7, "Welding Print Reading" *Fundamentals of Welding*, Unit 7, Objective 1—Terms related to print reading; Objective 2—Basic lines; Objective 13—Symbols
A.51 Discuss different types of drawings	*Fundamentals of Welding*, Unit 7, Objective 4—Isometric and oblique drawings
A.52 Interpret drawings — Bill of Materials — Revisions — Tolerances	*Fundamentals of Welding*, Unit 7, Objective 4—Isometric and oblique drawings; Objective 6—Tolerancing; Objective 15—Requirements for a formal bill of material; Objective 16—Requirements for an informal bill of material; Assignment Sheet 5—Interpret tolerance dimensions in decimals, fractions, and degrees; Unit 8, Assignment Sheet 5—Interpret a welding print and welding procedure specifications
A.53 Interpret symbols	*Fundamentals of Welding*, Unit 7, Objective 13—Symbols
Measurement Tools and Techniques	
A.54 Identify types of measuring instruments	*Fundamentals of Welding*, Unit 6, Objective 6—Types of rules and examples of their graduations
A.55 Use appropriate measurement instrument for a measurement task	*Fundamentals of Welding*, Unit 6, Job Sheet 2—Form 90° and 45° angles with a combination square and draw parallel lines on metal stock
A.56 Read measuring instruments	*Fundamentals of Welding*, Unit 6, Objective 7—Steps in reading a rule; Assignment Sheet 9—Measure distances with 1″, 1/2″, and 1/4″ graduations; Assignment Sheet 10—Measure distances with 1/4″ and 1/8″ graduations; Assignment Sheet 12—Measure distances with 1/16″ graduations; Job Sheet 1—Adjust a bevel square to a 45° angle using a framing square, a combination square, and a protractor; Job Sheet 2—Form 90° and 45° angles with a combination square and draw parallel lines on metal stock

Occupation: Shielded Metal Arc Welder	MAVCC Tasks
A.57 Identify the appropriate formula and units for a measurement task	*Fundamentals of Welding*, Unit 6, Objective 11—Squares, rectangles, and triangles and their formulas for calculating their perimeters; Objective 12—Area of geometric figures
A.58 Differentiate between English and Metric measurement systems, when necessary	*Fundamentals of Welding*, Unit 6, Objective 13—English-metric conversion charts and how to use them; Assignment Sheet 13—Make conversations with an English-metric conversion chart
A.59 Communicate measurements using proper symbols or words	*Fundamentals of Welding*, Unit 6, Objective 10—Units of measure and their equivalents
Duty B: Interpret Drawing and Welding Symbols and Written Welding Procedures	
B.01 Interpret basic elements of drawing/sketch	*GMAW and FCAW*—Unit 2, Job Sheets 5 through 8, 10 through 18, 20 through 24, 27 through 36, 38 through 40, 42 through 44; *Fundamentals of Welding*, Unit 7—Welding Print Reading (entire unit)
— Structural members	*Fundamentals of Welding*, Unit 7, Objective 14—Structural shapes
— Sequence of assembly	*Fundamentals of Welding*, Unit 7, Assignment Sheet 8—Construct adjacent parts in an assembly section
— Dimensions of tolerances	*Fundamentals of Welding*, Unit 7, Objective 5—Dimensioning; Objective 7—Methods of dimensioning; Assignment Sheet 5—Interpret tolerance dimensions in decimals, fractions, and degrees
— Scale	*Fundamentals of Welding*, Unit 7, Objective 9—Reduction and enlargement scales
— View interpretation	*Fundamentals of Welding*, Unit 7, Objective 3—Basic views; Objective 12—Types of section views; Student Supplement 2—Orthographic projection; Assignment Sheet 1—Construct a top view; Assignment Sheet 2—Construct a front view; Assignment Sheet 3—Construct a right side view; Assignment Sheet 7—Make a three-view sketch

— List of materials	*Fundamentals of Welding*, Unit 7, Objective 15—Requirements for a formal bill of materials; Objective 16—Requirements for an informal bill of materials
B.02 Interpret welding symbol information — Type of weld required — Filler metal — Special details — Non-destructive testing requirements	GMAW and FCAW—Unit 2, Job Sheets 5 through 8, 10 through 18, 20 through 24, 27 through 36, 38 through 40, 42 through 44. *Fundamentals of Welding*, Unit 8, Basic Welding Joints and Symbols (entire unit)
B.03 Interpret written welding procedures — Procedure ID number cross-referencing to drawing — Appropriate welding process/base materials/filler materials — Appropriate machine settings	*GMAW and FCAW*—Unit 2, "GMAW Equipment, Applications, and Techniques"—All job sheets
Duty C: Perform Shielded Metal Arc Welding	
Occupation: Shielded Metal Arc Welder	**MAVCC Tasks**
C.01 Perform safety inspection of equipment and accessories — Protective clothing and equipment — Cables — Communicate hazard warnings — Work areas	*SMAW and CAC—A*, Units 2 and 3 require student to inspect workplace before beginning a task, safely arrange equipment and materials, and maintain a hazard-free work area including proper shutdown of welding machine and safe storage of cables and other equipment.
C.02 Make minor external repairs to equipment and accessories (preventative maintenance only) — Manufacturer's recommendations — Company repair policy	*SMAW and CAC—A*, Units 2 and 3 require student to follow recommended guidelines for selecting tools and materials for all job sheets and to inspect the workplace before starting welding activity

C.03 Set up shielded metal arc welding on plain carbon steel plate and pipe — E7024, E6010, or E6011 and E7018 electrodes — Base/filler metal selection/ identification/preparation — Review appropriate weld procedures — Filler metal selection — Proper hand tool selection — Adjust voltage and polarity — Base metal preparation — Parts set up and preheated as necessary	*SMAW and CAC—A*, Unit 2, 32 job sheets guide student through practice with running a beadon plain carbon steel plate. Pipe welding is covered in MAVCC's *Shielded Metal Arc Pipe Welding*. Unit 2 job sheets (32 in all) have student weld fillet weld lap joints and T-joints in all positions, flat, horizontal, vertical, and overhead with E6010, E7024 and E7018 electrodes. Job sheets also have student weld V-groove butt joints in flat, horizontal, vertical and overhead positions with E6010 and E7018 electrodes. In all job sheets, student must complete basic metal preparation and adjust voltage and polarity for given application. V-groove preparation requires oxyacetylene preheating and cutting, and proceeds to cleaning and grinding to specifications. Student must prepare and conduct a bend test on V-groove joints.
Duty G: Perform Manual Oxyfuel (OF) Cutting	
Occupation: Shielded Metal Arc Welder	**MAVCC Tasks**
G.01, G.02, G.03, G.04, G.05, G.06, G.07, an G.09 cover safety, equipment use, and procedures for oxyfuel cutting.	See MAVCC's *Oxyacetylene Welding and Oxyfuel Cutting* for detailed duty/task. Unit 3, "Hardfacing" in MAVCC's *Shielded Metal Arc Welding and Carbon Arc Cutting—Air* contains Job Sheet 2 which provides an optional student preparation of test plates with oxyfuel cutting.
Duty I: Perform Air Carbon Arc Cutting (Gouging)	
Occupation: Shielded Metal Arc Welder	**MAVCC Tasks**
I.01, I.02, I.03, I.04, and I.05 cover safety, equipment use, and procedures for carbon arc cutting (gouging)	*Shielded Metal Arc Welding and Carbon Arc Cutting—Air*. Unit 4, "Carbon Arc Cutting—Air" has Job Sheet 1 which requires student to set up equipment, test air supply for moisture, and gouge a piece of mild steel. Job Sheet 2 of same unit requires student to backgouge a V-groove butt joint to assure complete fusion for the weldment.

Duty K: Perform Welding Inspection and Testing	
Occupation: Shielded Metal Arc Welder	**MAVCC Tasks**
K.01 Examine cut surfaces and edges of prepared base metal parts — Appearance — Uniformity — Proper fit-up — Base metal preparation	*SMAW and CAC—A*, Job sheets in Units 2 and 3 require student to inspect all welds from first bead quality to final pass for shielded metal arc welds on lap joints and T-joints in all positions. Students must also prepare mild steel V-groove butt joints for welding in all positions for welding and prepare a test specimen and conduct a bend test to evaluate all V-groove butt joint welds.
K.02 Examine tack, intermediate layers, and completed welds — Visual check for weld discontinuity and defects to an acceptable criteria — Destructive or non-destructive examination	*SMAW and CAC—A*, Job sheets in Units 2 and 3 require check of base metal before welding process begins, examination of initial bead and all passes and cleaning and visual inspections of final pass or bead. Specimens must be prepared to bend test V-groove butt joints, and specimens must be tested and evaluated.

Instructional/Task Analysis

Related Information: What the Student Should Know	Application: What the Student Should Be Able to Do
Unit 1: SMAW Safety	
1. Terms and definitions	10. Solve problems about shielded metal arc welding safety
2. Electrical safety for arc welding	
3. Rules for handling welding cables	
4. Rules for handling hollow castings and containers	
5. Hazards from arc ray	
6. Types of welding hoods	
7. Steps in selecting a safe lens shade for shielded metal arc welding	
8. Protective clothing required for arc welding	
9. Environmental problems and their safety requirements	
Unit 2: SMAW Equipment, Applications, and Techniques	
1. Terms and definitions	
2. Advantages of SMAW	
3. Principles of SMAW	
4. Relationship of arc, base metal, electrodes, and flux	
5. Elements of flux-covered electrode functions	
6. Benefits of learning SMAW	
7. Welding machines and their electrical characteristics	
8. Welding machines and their performance characteristics	
9. SMAW accessories and their purposes	
10. ASW electrode classifications for mild steel and low-alloy electrodes	
11. Stainless steel and other alloy electrodes	
12. Basic elements of arc welding and their importance	

Related Information: What the Student Should Know

Application: What the Student Should Be Able to Do

Unit 2: SMAW Equipment, Applications, and Techniques (cont.)

13. Elements of a good weld
14. Electrode angles
15. SMAW starting techniques
16. Controlling arc gap
17. Techniques for using electrode angles
18. Bead running techniques and their procedures
19. Techniques for stopping and restarting an arc
20. Techniques for filling a crater at the end of a weld
21. Using feathered edges for tie-ins
22. Basic steps in joint preparation
23. Good and bad welds and their characteristics
24. Causes of and remedies for arc blow
25. Causes of and remedies for pinholes and porosity
26. Causes of and remedies for undercutting
27. Causes of and remedies for weld splatter
28. Causes of and remedies for incomplete penetration
29. Causes of and remedies for slag inclusion
30. Causes of and remedies for excessive weld reinforcement
31. Electrode drying ovens

32. Start and restart an arc, crater, and backfill at the edge while running a bead on mild steel plate
33. Build a pad on mild steel plate in the flat position with an E6010 electrode .
34. Build a pad on mild steel plate in the flat position with an E7018 electrode
35. Weld to specifications a fillet weld lap joint in the flat position with an E6010 electrode
36. Weld to specifications a multipass fillet weld on a T-joint in the flat position with an E6010 electrode
37. Weld to specifications a fillet weld lap joint in the flat position with an E7018 electrode
38. Weld to specifications a multipass fillet weld on a T-joint in the flat position with an E7018 electrode.
39. Weld to specifications a fillet weld lap joint in the flat position with an E7024 electrode.
40. Weld to specifications a multipass fillet weld on a T-joint in the flat position with an E7024 electrode.
41. Weld to specifications a fillet weld lap joint in the horizontal position with an E6010 electrode
42. Weld to specifications a multipass fillet weld on a T-joint in the horizontal position with an E6010 electrode
43. Weld to specifications a fillet weld lap joint in the horizontal position with an E7018 electrode
44. Weld to specifications a multipass fillet weld in the horizontal position with an E7024 electrode
45. Weld to specifications a fillet weld lap joint in the horizontal position with an E7024 electrode

Related Information: What the Student Should Know	Application: What the Student Should Be Able to Do

Unit 2: SMAW Equipment, Applications, and Techniques (cont.)

46. Weld to specifications a multipass fillet weld on a T-joint in the horizontal position with an E7024 electrode
47. Weld to specifications a fillet weld lap joint in the vertical position with an E6010 electrode
48. Weld to specifications a multipass fillet weld on a T-joint in the vertical position with an E6010 electrode
49 Weld to specifications a fillet weld lap joint in the vertical position with an E7018 electrode
50. Weld to specifications a multipass fillet weld on a T-joint in the vertical position with an E7018 electrode
51. Weld to specifications a fillet weld lap joint in the overhead position with an E6010 electrode
52. Weld to specifications a multipass fillet weld on a T-joint in the overhead position with an E6010 electrode
53. Weld to specifications a fillet weld lap joint in the overhead position of an E7018 electrode
54. Weld to specifications a multipass fillet weld on a T-joint in the overhead position with an E7018 electrode
55. Weld to specifications a V-groove butt joint in the flat position with an E6010 electrode
56. Bend test a welded V-groove joint
57. Weld to specifications a V-groove butt joint in the horizontal position with an E6010 electrode
58. Weld to specifications a V-groove butt joint in the vertical position with an E6010 electrode
59. Weld to specifications a V-groove butt joint in the overhead position with an E6010 electrode
60. Weld to specifications a V-groove butt joint in the flat position with an E6010 electrode root and an E7018 electrode fill and cap.

Related Information: What the Student Should Know	Application: What the Student Should Be Able to Do
Unit 2: SMAW Equipment, Applications, and Techniques (cont.)	
	61. Weld to specifications a V-groove butt joint in the horizontal position with and E6010 electrode root and an E7018 electrode fill and cap
	62. Weld to specifications a V-groove butt joint in the vertical position with an E6010 electrode root and an E7018 electrode fill and cap
	63. Weld to specifications a V-groove butt joint in the overhead position with an E6010 electrode root and an E7018 electrode fill and cap
Unit 3: Hardfacing	
1. Terms and definitions	10. Build a pad on mild steel with a hardfacing electrode
2. Benefits of hardfacing	11. Prepare and hardface simulated bucket teeth
3. Arc welding methods used for hardfacing	
4. Types of wear and their characteristics	
5. Guidelines for applying weld deposits	
6. Ventilation safety for hardfacing	
7. Heat treating cautions	
8. Guidelines for heavy construction hardfacing	
9. Hardfacing electrode hardness ratings	
Unit 4: Carbon Arc Cutting—Air	
1. Terms and definitions	12. Gouge a piece of mild steel with the air carbon arc process
2. Air carbon arc cutting	13. Backgouge a selected weld to prepare it for welding on the other side
3. Air carbon arc power sources	
4. Carbon arc electrodes and their characteristics	
5. Electrode shapes and their applications	
6. Electrode angles and their characteristics	
7. Amperage selection for gouging	
8. Air pressure and how it affects gouging	
9. Travel speed and how it affects gouging	
10. Techniques for gouging and their procedures	
11. When to use backgouging	

Basic Skills Icons and Classifications

To assist teachers and students in identifying and documenting where academic and workplace skills are being taught, MAVCC has adopted a system that uses icons and a list of specific tasks to identify the skill or skills that are used in each focus assignment, assignment sheet, and job sheet.

A matrix for each of the ten broad skill areas has been included in this edition and reflects key elements from *What Work Requires of Schools: A SCANS Report for America 2000*, a 1991 study by the U.S. Department of Labor; *Workplace Basics: The Skills Employers Want*, a three-year study conducted jointly by the American Society for Training and Development (ASTD) and the United States Department of Labor (DOL); and other national and state sources.

Each of the ten broad skill areas—reading, writing, mathematics, science, oral communication, interpersonal or relating, critical thinking, employability, social studies, and technology—is represented by the icon presented below.

Reading Skills

- Reading Comprehension
- Research/Reference
- Functional Reading

Writing Skills

- Language
- Composition
- Research
- Functional Writing

Math Skills

- Operation and Calculation
- Math Application
- Data Analysis and Display
- Functional Math

Basic Skills Icons and Classifications

Science Skills

- General Science
- Life Science
- Physical Science
- Earth Science

Oral Communication Skills

- Oral Presentation
- Listening
- Interactive Communication

Interpersonal or Relating Skills

- General Relating
- Teamwork/Cooperation
- Leadership/Influence

Critical Thinking Skills

- Cognitive Activities

Employability Skills

- Job Search/Selections
- Job Acquisition/Development
- Resource Management
- Job Safety

Social Studies Skills

- Information Analysis
- Social Studies Application
- Functional Social Studies

Technology Skills

- Selection
- Application
- Maintenance/Troubleshooting

Reading Skills

Reading Comprehension

- Gain factual information
- Distinguish fact, opinion, and inference
- Recognize stereotyping and bias
- Recognize propaganda
- Analyze cause and effect
- Draw conclusions
- Make generalizations
- React to written material
- Apply word analysis techniques
- Analyze and apply what has been read to specific task
- Comprehend written information for main ideas
- Determine what information is needed

Research/ Reference

- Select useful resources
- Locate resources
- Find materials in library
- Use standard references
- Use in-book reference tools
- Use audiovisual media
- Use computer database
- Use magazines and newspapers

Functional Reading

- Interpret forms and records
- Follow written instructions
- Interpret graphics and symbols
- Interpret abbreviations/acronyms
- Read aloud
- Apply/understand technical words that pertain to subject

Basic Skills Icons and Classifications

Writing Skills

Language

- Use standard grammar, spelling, and capitalization
- State ideas clearly

Composition

- Use complete sentences
- Develop preliminary outline
- Use topic sentences
- Use introductory/closing paragraphs
- Compose reports
- Compose essays
- Proofread and edit
- Construct graphics and symbols

Research

- Take notes
- Use note cards
- Create bibliography
- Use footnotes
- Outline material

Functional Writing

- Complete forms and records
- Write instructions
- Write letters
- Write job applications
- Write resumes
- Use word processing
- Use computer graphics
- Use content area vocabulary

Math Skills

Operation and Calculation	• Round off numbers • Estimate answers • Use scientific notations • Use exponential notations • Calculate with whole numbers • Calculate with fractions • Calculate with decimals • Convert whole numbers to fractions • Convert whole numbers to decimals • Solve numerical expressions • Solve formulae and equations • Obtain squares and square roots • Convert units of measure • Perform metric calculations
Math Application	• Solve word problems • Select/apply mathematical formula • Select/apply mathematical procedure • Use English and metric measures • Solve time/rate/distance problems • Solve ratio/proportion problems • Solve percent problems • Apply techniques of scaling • Apply algebra principles • Apply geometry principles • Apply trigonometry principles
Data Analysis and Display	• Interpret charts and tables • Interpret graphs • Collect/record data • Apply sampling techniques • Apply principles of probability • Construct charts and tables • Construct graphs • Calculate statistics • Interpret statistics • Interpret plans/blueprints • Draw facility to scale

Math Skills (Continued)

Functional Math

- Make measurements
- Perform banking transactions
- Make change
- Solve practical problems
- Calculate gross earnings
- Solve income/expense problems
- Prepare a budget
- Calculate interest
- Solve interest problems
- Calculate sales tax
- Determine income tax
- Use calculator for computation
- Use computer for computation
- Use computer spreadsheets
- Apply computation skills as they are actually used on the job
- Calculate measurements taken from measuring devices
- Perform/prepare an inventory
- Calculate and compare shipping costs
- Prepare financial report

Science Skills

General Science

- Apply computing skills
- Apply scientific method of inquiry
- Conduct experiments
- Investigate science ethics
- Investigate science history
- Investigate/apply economics in technology
- Use scientific instruments
- Investigate/apply technology
- Collect specimens
- Construct model to depict basic concept of ----

Life Science

- Identify/classify living organisms
- Investigate biological history of the earth
- Investigate food chains, webs, pyramids
- Investigate/apply principles of human development
- Investigate/apply principles of genetics/heredity
- Investigate/apply principles of anatomy/physiology
- Investigate health issues
- Observe health code/sanitation requirements

Physical Science

- Analyze/classify matter
- Investigate forms/changes of matter
- Investigate forms/changes of energy
- Investigate/apply chemical properties
- Investigate/apply physical laws

Earth Science

- Investigate physical characteristics of the earth
- Investigate geological history of the earth
- Investigate physical forces acting on the earth
- Solve problems of longitude, latitude, and time zones
- Investigate conservation of physical resources
- Investigate conservation of living resources
- Investigate issues of environmental impact
- Apply science principles to environmental issues

Oral Communication Skills

Oral Presentation

- Make informative presentations
- Make persuasive presentations
- Present personal opinion/viewpoint
- Use good speaking techniques
- Select/use words effectively
- Use effective body language
- Present appropriate appearance
- Integrate audio and/or visual materials into oral presentations
- Adapt presentation to specific audience

Listening

- Apply active listening skills
- Distinguish fact, opinion, and inference
- Draw conclusions/make generalizations
- Analyze/identify point of view

Interactive Communication

- Give/follow oral directions
- Apply questioning techniques
- Conduct/receive interviews
- Analyze/apply nonverbal communication
- Work effectively in a group
- Communicate with clients/customers/patients
- Communicate with coworkers
- Communicate with supervisors
- Communicate with professional colleagues/associates
- Apply telephone etiquette

Interpersonal or Relating Skills

General Relating

- Investigate/apply communication process models
- Analyze/apply nonverbal communication
- Investigate/apply cross-cultural communication
- Interact with coworkers
- Interact with supervisors
- Interact with clients/customers/patients
- Interact with professional colleagues/associates
- Interact with family/friends
- Participate in group activities
- Participate in industrial relations/functions
- Identify personal values/attitudes
- Apply information to life experiences

Teamwork/ Cooperation

- Identify values/attitudes
- Identify needs/drives
- Select/apply appropriate behavior
- Investigate/identify personal styles
- Investigate/identify group/corporate climate
- Give/receive feedback
- Identify hidden purposes
- Investigate/apply group dynamics
- Control undesirable/inappropriate behavior
- Resolve conflicts
- Clarify goals/objectives
- Devise "win/win" situations
- Build consensus
- Generate ideas
- Present point of view

Leadership/ Influence

- Analyze/apply leadership styles
- Analyze/apply management styles
- Obtain confidence of others
- Develop esteem in self/others
- Persuade others
- Analyze/apply motivation techniques
- Provide positive coaching

Critical Thinking Skills

Cognitive Activities

- Collect/record information
- Identify critical elements/issues
- Define a problem
- Identify underlying causes
- Apply a problem-solving model
- Analyze/synthesize information
- Identify/analyze underlying assumptions
- Draw conclusions
- Predict results/outcomes
- Identify/evaluate consequences
- Identify/develop alternatives
- Evaluate alternatives
- Select an alternative
- Devise a solution
- Create a finished product
- Apply intuitive thinking techniques
- Transfer knowledge/training to new situations
- Apply new technology
- Develop an action plan
- Evaluate results/outcomes
- See relationship between two or more ideas, objects, or situations

Employability Skills

Job Search/ Selections

- Analyze personal occupational aptitudes/preferences
- Investigate employment prospects of a career field/occupation
- Investigate training requirements for a career field/occupation
- Investigate benefits of a career field/occupation
- Compare/evaluate career options
- Analyze impact of work on individual and family life

Job Acquisition/ Development

- Develop personal career path
- Locate appropriate jobs
- Analyze duties/requirements/benefits of specific job
- Master specific job task/procedure
- Complete job-related applications
- Write a letter of application
- Write personal resume
- Interview for a job
- Apply business etiquette
- Practice good work habits/attitudes
- Practice good personal presentation
- Develop self confidence/esteem
- Develop effective leadership
- Deal effectively with supervisors
- Deal effectively with coworkers
- Deal effectively with professional colleagues/associates
- Deal effectively with customers/clients/patients
- Follow established rules, regulations, and policies
- Promote the goals and values of the organization
- Exert a high level of effort and perseverance towards goal attainment
- Set high standards for self in completion of a task

Resource Management

- Complete task in timely manner
- Determine cost, time, and resources to complete a task
- Perform routine tasks related to equipment operation and/or maintenance

Job Safety

- Demonstrate safe use of tools, equipment, and supplies
- Observe safety rules
- Wear safety equipment
- Follow safety procedures
- Demonstrate proper use of safety device

Social Studies Skills

Information Analysis

- Collect/record data
- Interpret graphical information
- Construct graphical information
- Interpret maps/globes
- Interpret statistical information
- Analyze/interpret demographic information
- Distinguish trends and predicts impact of actions on systems operations

Social Studies Application

- Investigate/apply U.S. history
- Investigate/apply world history
- Investigate/apply U.S. geography
- Investigate/apply world geography
- Investigate/apply principles of government/politics
- Investigate/apply principles of economics
- Investigate/apply principles of ethics
- Investigate/apply principles of sociology
- Investigate/apply cross-cultural studies

Functional Social Studies

- Practice responsible personal economics
- Prepare a personal budget
- Use credit responsibly
- Practice good work ethics
- Participate in industrial relations
- Interact with people of different races/cultures
- Investigate/participate in government
- Investigate/apply American legal practices
- Select/use sources of information on current events
- Analyze current events
- Analyze consumer issues
- Analyze social issues
- Analyze conservation/ecology issues
- Analyze social impact of science/technology
- Analyze economic impact of science/technology
- Understand how social, organizational, and technological systems work and operate effectively

Technology Skills

Selection	• Choose procedures, tools, or equipment including computers and related technologies that will produce the desired results
Application	• Demonstrate the proper procedures for setting up and operating equipment, including computers and their programming systems
Maintenance/ Troubleshooting	• Perform maintenance on equipment, including computers and other technologies • Identify and correct problems with equipment • Report damaged or broken equipment to appropriate individual

Shielded Metal Arc Welding and Carbon Arc Cutting—Air

BASIC SKILLS MATRIX

	Reading	Writing	Mathematics	Science	Oral Communication	Interpersonal	Critical Thinking	Employability	Social Studies	Technology
Unit 1 SMAW Safety	X	X					X	X		
Unit 2 SMAW Equipment, Applications, and Techniques	X		X	X			X	X		X
Unit 3 Hardfacing	X		X	X			X	X		X
Unit 4 Carbon Arc Cutting—Air	X		X	X			X	X		X

Tools, Equipment, and Materials List

Assortment of welding lens shades
Bench vice
Chipping hammer
Face shield
File
Fire extinguisher
Fitter's hammer
Gouging equipment complete with compressed air supply
Gouging electrodes
Ground clamp
Hand-held grinder
Hardfacing electrodes as selected by instructor
Mild steel plate
Oxyacetylene cutting unit
Personal safety clothing
Pliers
Safety glasses
SMAW electrode and work leads
SMAW electrode holder
SMAW electrodes: E6010, E7018, E7024 and others at instructor's option
SMAW welding machine
Spring clamp
Welding helmet
Wire brush
Work station shielding screens

Unit Contents

Teacher Components

	Teacher Page
Suggested Activities	1–3
Answers to Assignment Sheet	1–7
Written Test	1–9
Answers to Written Test	1–15

Student Components

	Student Page
Learning Activities Sheet	1–3
Objective Sheet	1–5
Information Sheet	1–7
*Assignment Sheet	
1—Solve Problems Concerning SMAW Safety	1

*The Assignment Sheet is located in the Student Workbook.

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss the assignment sheet. Review with students the criteria for evaluation of this activity.

Suggested Activities

Teaching Suggestions

- Give students a tour of the facilities in which they will be working. Point out the location of fire extinguishers, escape routes in the event of a fire, and other elements related to safety in the workplace.
- Invite a local welding shop owner or contractor to talk to the class about working in situations that pose added risks or hazards, jobs that require welding in high places, welding in confined spaces, or welding in outdoor areas where property and people should both be a prime concern of the welder.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.
- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.
- Evaluate the assignment sheet. Rate the student using the criteria listed on the assignment sheet. See Answers to Assignment Sheet for correct answers where applicable. If the student's performance is unacceptable, have the student review the appropriate materials and complete the assignment again.
- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- Connor, Leonard, P., ed. *Welding Technology, Welding Handbook*, 8th ed. Vol. 1. Miami, FL: American Welding Society, 1987.
- O'Brien, R.L., ed. *Welding Processes, Welding Handbook*. 8th ed. Vol. 2. Miami, FL: American Welding Society, 1991.
- *OSHA Safety and Health Standards (29 CFR 1910) Revised*. Washington, DC: U.S. Department of Labor, Occupational Safety and Health Administration.
- *Welding and Fabricating Data Book*. Cleveland, OH: Penton Publishing Inc.

Suggested Supplemental Resources

Print Media

- *Arc Welding and Cutting Noise*—Standardized measurements of noise generated by welding and cutting processes. 40 pages. Catalog no. AWN

- *Arc Welding Safely*—Safety guide every welder should be given. 9 pages. Catalog no. AWS

The two printed publications listed above are available from:

American Welding Society
550 N.W. LeJeune Road
Miami, FL 33126
800.854.7179
http://www.aws.org

Electronic Media

- Videos

  — *Arc Welding Safety* (11 min.)—This video provides a review of arc welding safety, safety hazards, and health hazards associated with this type of welding operation. (English and Spanish) 1011H

  — *Health and Safety Factors in Welding Operation* (27 min.)—This video educates welders on potential health and safety concerns in this occupation. 9018A

  The videos listed above are available from MAVCC at www.mavcc.org, or call 800.654.3988. Most videos are also available in CD-ROM format.

  — *Welding Safely—The Way The Pros Do It* (Item no. ED-209)—Available from:

  The Lincoln Electric Company
  22801 St. Clair Avenue
  Cleveland, OH 44117-1199
  Fax: 216.881.2326

Answers to Assignment Sheet

Assignment Sheet 1

Solve Problems Concerning SMAW Safety

Note: Student answers should approximate those given.

1. Yes. The welding machine should be disconnected from the power source.
2. Yes. Only a dry rag should be used to clean a welding cable.
3. Yes. Erect a shielding curtain or panel around the work area.
4. Yes. Use a minimum #8 lens shade and take a position that will provide better visibility.
5. Yes. A welding cap pulled down over the left ear would eliminate the hazard.
6. Yes. A face shield should also be worn when grinding.

Written Test

Name _____

Date _____ Score _____

Objective 1

Match the terms with their definitions.

1. Contaminants
2. Oxygen displacement
3. Toxic hazards

_____ a. Poisonous gases, fumes, and vapors produced by chemical reactions in certain welding processes

_____ b. The tendency of any arc or flame to reduce oxygen in the breathing zone around a welding activity

_____ c. Elements in the atmosphere and/or impurities formed from chemical reactions between a base metal, filler metal, electrode, or shielding gas

Objective 2

Select true statements concerning electrical safety for arc welding by placing an "X" in the blanks next to the true statements.

_____ a. All electrical equipment should have an earth ground for safety reasons, and this ground should not be confused with the work lead to workpiece ground that completes the welding circuit.

_____ b. Keep electrical connections tight, clean, and dry because poor connections can heat up, cause bad welds, produce dangerous arcs and sparking, and even melt.

_____ c. Keep work area, equipment, and clothing dry because even a slight amount of moisture can conduct enough electricity to cause a severe shock.

_____ d. Dip an electrode holder in water to cool it.

_____ e. When working with welding machines set up for multiple operation, be very careful not to touch hot parts of the electrode holders because open-circuit voltages from two machines are increased and can cause a severe shock.

_____ f. Remove electrode from electrode holder when work is finished.

_____ g. Disconnect and lock out all electric power sources before doing any work on electrical equipment.

_____ h. When working in high places, carefully examine work area for electrical hazards because a shock in such conditions could cause a fall and severe injury.

_____ i. Keep welding cables free of conduits, motors, and any other equipment that could cause a short circuit.

_____ j. Keep ground as near to the arc as possible.

Objective 3

Complete statements concerning rules for handling welding cables by circling the information that best completes each statement.

a. Never drag a welding cable through **(dirt) (oil)** and never pull on a cable to force it over an obstruction.

b. Use only **(rags dipped in cleaning solvent) (clean, dry rags)** to clean welding cables, and never use gasoline or an oily rag to clean a cable.

c. When not in use, keep welding cables free of **(kinks) (dirt)** and properly stored **(on a peg on a wall) (on a flat surface off the floor)**.

d. Never drape a welding cable over any type of **(metal) (gas cylinder)**.

Objective 4

Complete statements concerning rules for handling hollow castings and containers by circling the information that best completes each statement.

a. Hollow castings or containers should be **(filled) (vented)** before any heating, cutting, or welding activity.

b. Tanks, drums, and containers **(should not be) (can usually be)** heated, cut, or welded.

c. The rule for beginning welders is to never attempt heating, cutting, or welding on **(barrels that have held solvent) (hollow castings or containers)**.

Objective 5

Select solutions for hazards from arc rays by circling the best response to each of the following conditions.

a. A welder is arc welding and wearing a welding helmet, the right lens shade, and safety glasses, but the welder is in a short sleeve shirt.

(1) The welder is safe so long as welding is done in a hurry.
(2) The welder needs to have hands, arms, legs, and torso covered with durable flame-resistant clothing.
(3) The welder needs gloves with extremely long gauntlets.

b. The arc flash from an arc welding station is clearly visible to people who have to walk to the shop office.

(1) People should be directed to take another route.
(2) People should be given shaded-lens glasses.
(3) The work area should have a shield around it to contain the arc flash.

Objective 6

Solve problems concerning guidelines for duty cycle safety by circling the number of the item that best solves each of the following problems.

a. You are working with a SMAW machine that has a duty cycle of only 10 percent. You know to:

(1) Increase amperage to accomplish more welding in a shorter time.
(2) Pay careful attention to the actual time you spend welding.
(3) Stop every ten minutes to let the machine cool.

b. You are working with a SMAW machine that has a 20 percent duty cycle. You estimate the welding job will take at least 30 minutes. You know to:

(1) Operate the machine 6 minutes and then allow it to cool for 6 minutes.
(2) The duty cycle will cover the entire time span so just complete the weld and be done with it.
(3) Operate the machine no more than 2 minutes out of each 10 minute period.

Objective 7

Complete statements concerning types of welding hoods and their characteristics by circling the material that best completes each statement.

a. Stationary filter lens—This type hood has a **(fixed) (flexible)** lens housing with the shaded lens held in by a spring retainer from where a lens can be slipped out and replaced as welding requires.

b. Flip-front filter lens—This type hood has a lens housing with a front side that can be flipped up so that it leaves a **(dark) (clear-glass or plastic)** lens that permits the hood to be worn while chipping.

c. Auto darkening lens—This type of lens contains sensors that automatically change the shade lens from **(clear to dark) (dark to clear)** in a fraction of a second when you start to weld.

Objective 8

Complete a list of steps in selecting a safe lens shade for Shielded Metal Arc Welding and Carbon Arc Cutting—Air by circling the information that best completes each of the following statements.

a. Determine electrode size and amperage range for the **(electrode) (joint design)**.

b. Select lens shade according to the lens manufacturer's selection chart, but never select less than a **(#5) (#8)** lens shade for Shielded Metal Arc Welding and Carbon Arc Cutting—Air.

c. A rule of thumb is that the larger the diameter of the electrode, the **(lower) (higher)** the number required for a lens shade.

Objective 9

Solve problems concerning protective clothing required for arc welding by circling the best solution to each of the following scenarios.

a. For a welding job where there would be a danger that flying sparks might strike a welder around the head and ear area, what could make the situation safe?

(1) Moving the job to a safer area.
(2) Make sure the welder wears a welder's cap underneath the welding helmet and turns the bill to protect the ear opening on the side where sparks might fall.
(3) Take a different welding position.

b. For a welding job that poses the danger that flying sparks and metal splatter might fall on a welder's legs, what could make the situation safer?

(1) Wear heavy leather boots that reach above the ankle, and cuffless pants.
(2) Wear good gloves.
(3) Wear a welding jacket.

c. For a welding job that poses danger from other construction materials falling from above, what could make the situation safer?

(1) Build a covered frame over the welding area.
(2) Have the welders wear hard hats.
(3) Postpone welding until workers above have finished with their job.

d. For a welding job that will require a welder to be welding out of position in a confined area, what could make the situation safer?

(1) Have the welder move to another position.
(2) Have the welder wear a leather jacket along with a welder's cap.
(3) Have the welder wear a hard hat.

Objective 10

Solve problems concerning environmental safety requirements by circling the number of the best solution to each of the following problems.

a. Ventilation—Many welding activities produce **(smoke) (toxic fumes)** and vapors that are hazardous to breathe, and every workstation should be equipped with a ventilation or exhaust system capable of safely removing dangerous and irritating smoke and contaminants.

b. Respirators—Working in confined areas where toxic fumes are a hazard requires wearing a respirator that can compensate for **(oxygen displacement) (smokey air)** but irritation form other welding fumes and gases can be avoided by wearing a respirator with a filter-type mask.

c. Noise—This is a workplace hazard frequently overlooked, but earplugs or muffler-type ear protectors should be worn when the work area subjects a welder to high noise levels, especially high noise levels that are **(continuous) (irritating)**.

d. Lighting—Lighting in a work area or at a workstation should be bright enough to provide good visibility free of glare because poorly lit work areas contribute to eye fatigue, irritation, and **(poor work) (general health problems)**.

*Permission to duplicate this test is granted.

Answers to Written Test

Objective 1

a. 3
b. 2
c. 1

Objective 2

a, b, c, e, f, g, h, i, j

Objective 3

a. Oil; an obstruction
b. Clean, dry rags
c. Kinks; on a flat surface off the floor
d. Gas cylinder

Objective 4

a. Vented
b. Should not be
c. Hollow castings or containers

Objective 5

a. 2
b. 3

Objective 6

a. 2
b. 3

Objective 7

a. Fixed
b. Clear glass or plastic
c. Clear to dark

Objective 8

a. Electrode
b. #8
c. Higher

Objective 9

a. 2
b. 1
c. 2
d. 2

Objective 10

a. Toxic fumes
b. Oxygen displacement
c. Continuous
d. Poor work

Unit Contents

Teacher Components

	Teacher Page
Suggested Activities	2–3
Written Test	2–11
Answers to Written Test	2–25
Transparency Masters	
1—Mild Steel Electrode Groups	2–29
2—Selection Data for Mild Steel Electrodes	2–31
3—Selection Data for Stainless Steel and Other Alloy Electrodes	2–33
4—Electrode Sizes	2–35
5—Basic Motions for Electrode Manipulation	2–37
6—Typical Welded Joints and Positions	2–39
7—Good and Bad Welds	2–41

Student Components

	Student Page
Learning Activities Sheet	2–3
Objective Sheet	2–5
Information Sheet	2–9
Student Supplement	
1—Electrode Selection Carbon and Low Alloy Steel	2–31
*Job Sheets	
1—Start and Restart an Arc, Crater, and Backfill at the Edge While Running a Bead on Mild Steel Plate	3
2—Build a Pad on Mild Steel Plate in the Flat Position with an E6010 Electrode	9
3—Build a Pad on Mild Steel Plate in the Flat Position with an E7018 Electrode	15
4—Weld to Specifications a Fillet Weld Lap Joint in the Flat Position with an E6010 Electrode	21
5—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Flat Position with an E6010 Electrode	25
6—Weld to Specifications a Fillet Weld Lap Joint in the Flat Position with an E7018 Electrode	29
7—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Flat Position with an E7018 Electrode	33
8—Weld to Specifications a Fillet Weld Lap Joint in the Flat Position with an E7024 Electrode	37
9—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Flat Position with an E7024 Electrode	41
10—Weld to Specifications a Fillet Weld Lap Joint in the Horizontal Position with an E6010 Electrode	45

Unit Contents

11—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Horizontal Position with an E6010 Electrode 49
12—Weld to Specifications a Fillet Weld Lap Joint in the Horizontal Position with an E7018 Electrode 53
13—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Horizontal Position with an E7018 Electrode 57
14—Weld to Specifications a Fillet Weld Lap Joint in the Horizontal Position with an E7024 Electrode 61
15—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Horizontal Position with an E7024 Electrode 65
16—Weld to Specifications a Fillet Weld Lap Joint in the Vertical Position with an E6010 Electrode 69
17—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Vertical Position with an E6010 Electrode 73
18—Weld to Specifications a Fillet Weld Lap Joint in the Vertical Position with an E7018 Electrode 77
19—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Vertical Position with an E7018 Electrode 81
20—Weld to Specifications a Fillet Weld Lap Joint in the Overhead Position with an E6010 Electrode 85
21—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Overhead Position with an E6010 Electrode 89
22—Weld to Specifications a Fillet Weld Lap Joint in the Overhead Position with an E7018 Electrode 93
23—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Overhead Position with an E7018 Electrode 97
24—Weld to Specifications a V-Groove Butt Joint in the Flat Position with an E6010 Electrode 101
25—Bend Test a Welded V-Groove Joint 107
26—Weld to Specifications a V-Groove Butt Joint in the Horizontal Position with an E6010 Electrode 111
27—Weld to Specifications a V-Groove Butt Joint . . . . . in the Vertical Position with an E6010 Electrode 117
28—Weld to Specifications a V-Groove Butt Joint in the Overhead Position with an E6010 Electrode 123
29—Weld to Specifications a V-Groove Butt Joint in the Flat Position with an E6010 Electrode Root and an E7018 Electrode Fill and Cap 129
30—Weld to Specifications a V-Groove Butt Joint in the Horizontal Position with an E6010 Electrode Root and an E7018 Electrode Fill and Cap 135
31—Weld to Specifications a V-Groove Butt Joint in the Vertical Position with an E6010 Electrode Root and an E7018 Electrode Fill and Cap 141
32—Weld to Specifications a V-Groove Butt Joint in the Overhead Position with an E6010 Electrode Root and an E7018 Electrode Fill and Cap 147

*The Job Sheets are located in the Student Workbook.

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.
- Make transparencies from the transparency masters included in this unit. These appear in the teacher edition only.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Suggested Activities

Teaching Suggestions

- Discuss area manufacturers who employ welders in their facilities, and the types of welding jobs that students from your program move on to.

- Demonstrate all elements of the job sheets, including oxyacetylene cutting, and stress safety at all points in your demonstration.

- Because this is an extremely long unit of instruction, break the unit into parts that will be easier to present and evaluate. The job sheets present students the challenge of mastering the welding of basic joints in all positions. These hands-on activities may be presented in groups of joints—lap, groove, corner, or T-joint, or in position groups—flat, horizontal, vertical, or overhead. In other words, because the job sheets are ordered by number, it does not mean that a student must complete them in a specific order. Choose the order that best accommodates students and makes optimal use of your welding facility. Be sure to modify the Learning Activities Sheet as applicable.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.

- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.

- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

  Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

Sample A

4—**Skilled**—Can perform job with no additional training.
3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
1—**Unskilled**—Is familiar with process, but is unable to perform job.
0—**No exposure**—No information or practice provided during training program.

Sample B

Yes—Can perform job with no additional training.
No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- Althouse, Andrew D., Carl H. Turnquist, and William A. Bowditch. *Modern Welding*, 9th ed. South Holland, IL: The Goodheart-Willcox Co., Inc., 2000.
- Connor, Leonard, P., ed. *Welding Technology, Welding Handbook*, 8th ed. Vol. 1. Miami, FL: American Welding Society, 1987.
- *New Lessons in Arc Welding* Cleveland, OH: The Lincoln Electric Company, 1981.
- O'Brien, R.L., ed. *Welding Processes, Welding Handbook*. 8th ed. Vol. 2. Miami, FL: American Welding Society, 1991.
- *The Procedure Handbook of Arc Welding*. 13th ed. Cleveland, OH: The Lincoln Electric Company, 1994.
- *2000 Lincoln Global Inc.* Cleveland, OH: The Lincoln Electric Company, 2000.0

Suggested Supplemental Resources

Print Media

- *Principles of Arc Welding*—This informational booklet for beginners covers the fundamentals of SMAW such as techniques for striking the arc, running beads, basic joints, and out-of-position welding. (18 pages) Available from:

  Miller Electric Manufacturing Co.
  1635 W. Spencer St.
  P.O. Box 1079
  Appleton, WI 54912-1079
  920.734.9821
  www.millerwelds.com

- Posters

  — *Shielded Metal Arc Welding and Carbon Arc Cutting—Air (SMAW)* (Item no. EW-271)

  — *Types of Welds* (Item no. EW-272)

  — *Welding Positions* (Item no. EW-476)

  — *Typical Weld Joint Symbols* (Item no. EW-477)

  — *Examples of Good and Bad Beads* (Item no. EW-486)

  The posters listed above are available from:

  Hobart Institute of Welding Technology
  400 Trade Square East
  Troy, OH 45373
  800.332.9448 ext. 5433
  www.welding.org

Electronic Media

- Videos

  — *Introduction to Welding (Shielded "Stick")*—This video covers welding basics that will help students correctly and safely strike and maintain an arc, run a bead, and make several types of basic welds. The featured expert offers insight and instruction on basic safety and operation techniques, common equipment, electrodes, and metal identification. 28 min. (C00839)

  — *Shielded "Stick" Metal Arc Welding I*—This video begins with safety precautions, inspection of equipment, and proper work clothing for welding. It then shows how to set up and adjust an AC/DC, a rectifier AC, and a standard AC welder. Close-up footage of nine welds (including stringers, butt-weld, lap-weld, T-weld, multi-pass fillet) performed in the flat position is presented, although welding techniques in straight, crescent and up-and-back motions are also demonstrated. 45 min. (C00810)

  — *Shielded "Stick" Metal Arc Welding II*—Features on-location footage and performance of 13 welds, including horizontal stringer, horizontal butt, vertical down stringer, vertical up stringer, vertical down butt, vertical up butt, vertical up lace, vertical up, vertical up E7018, overhead stringer, overhead lap and overhead butt welds. 27 min. (C00811)

  — *Shielded "Stick" Metal Arc Welding III*—Features the "guided bend" and "nick-break" methods of testing welds. Includes preparation of metal for test samples, performing welds and preparation of specimens for testing. Tests are made and evaluated. Includes a summary of essentials for successful welding, including metal identification. 27 min. (C00818)

  The videos listed above are available from MAVCC at www.mavcc.org, or call 800.654.3988.

  — *Arc Welding Explained (Tape 2: Shielded Metal-Arc Welding)*— 18 min. ISBN 0-8064-1364-6. Available from:

  Delmar Publishing
  3 Columbia Circle
  P.O. Box 15015
  Albany, NY 12212-5015
  800.347.7707
  www.delmar.com

— *Introduction to Welding: Shielded Metal Arc Welding and Carbon Arc Cutting—Air*—This video shows how an electrical current melts electrodes to supply filler metal and explains the differences between alternating current and direct current arc welding machines. Set-up and shut-off instructions are shown step-by-step as well as how to use equipment safely. (12 min.) Available from:

Glencoe/McGraw-Hill
P.O. Box 508
Columbus, OH 43216
800.334.7344
www.glencoe.com

— *High Speed Studies of the Welding Arc*—This video shows a gas metal arc in short circuiting, globular and spray modes. Also FCAW, SMAW, GTAW, and plasma arc in keyhole mode. EW-637

— *Shielded Metal Arc Welding and Carbon Arc Cutting—Air Basic*—Consists of 8 tapes covering basic SMAW processes. V01.0

— *Shielded Metal Arc Welding and Carbon Arc Cutting—Air Advanced 1*—Consists of 4 tapes covering structural welding, safety, and advanced SMAW processes. V02.0

— *Shielded Metal Arc Welding and Carbon Arc Cutting—Air Advanced 2*—Consists of 3 tapes covering safety and more advanced SMAW processes. V05.0

The three video packages listed above are available from:

Hobart Institute of Welding Technology
400 Trade Square East
Troy, OH 45373
800.332.5433 ext. 5433
www.welding.org

— *Arc Welding Methods*—This video provides a general overview of Stick, MIG, TIG and Submerged Arc. Topics covered in the program include what these four major processes have in common, as well as how they differ, and where they are used. (24 min) Available from:

Miller Electric Manufacturing Co.
1635 W. Spencer St.
P.O. Box 1079
Appleton, WI 54912-1079
920.734.9821
www.millerwelds.com

— *Learn to Weld—The Lincoln Way* (Item no. ED-201)

— *Welding—Making It Happen* (Item no. ED-204)

The two videos listed above are available from:

The Lincoln Electric Company
22801 St. Clair Avenue
Cleveland, OH 44117-1199
Fax: 216.881.2326

— *Introduction to Shielded Metal Arc Welding and Carbon Arc Cutting—Air #1; Arc Welding Safety #2; Striking Arcs with E-6010 / Cellulose Electrodes #3; Striking Arcs with E-7018 / Low Hydrogen Electrodes #4; Stringer Beads with E-6010 #5; Stringer Beads with E-7018 #6; Weave Beads #7; Restarts of Beads #8; Welding Tips and Techniques #9; Groove Weld, Square, Flat Position #10; Fillet Joint, Horizontal #11* These videos are available from:

Tel-A-Train, Inc.
A Primedia Company
309 N. Market Street
Chattanooga, TN 37421
Tel: 1-800-568-8788 ext. 5447
http://www.telatrain.com

- CD-ROMs

— *Fundamentals of Arc Welding*—This CD consists of twelve segments that cover the following: welding in the flat, vertical, horizontal, and overhead positions; reading and interpreting basic welding symbols; welding processes and welding joints; welding safety; common destructive ad nondestructive testing methods; and other welding topics. CDs are available in Spanish and English. Available from:

Storck Interactive Training, Inc.
P.O. Box 349
4345 Highway 33 W
West Bend, WI 53095
262.335.9796

— *Introduction to Welding*—An interactive program created to build welding knowledge step-by-step, leading to "hands-on" welding. Available from:

Miller Electric Manufacturing Co.
1635 W. Spencer St.
P.O. Box 1079
Appleton, WI 54912-1079
920.734.9821
www.millerwelds.com

Written Test

Name _____

Date _____ Score_____

Objective 1

Match the terms with their definitions.

1. Air contaminants	4. Deposition rate	7. Shielding
2. Axis of a weld	5. Filler pass	8. Slag
3. Cap pass	6. Root bead	9. Stringer bead

_____ a. A type of weld bead made without appreciable weaving motion

_____ b. The remainder of the beads required to complete the joint from the root bead out to the cap pass

_____ c. Hydrogen, oxygen, and nitrogen in air

_____ d. A weld bead that extends into or includes parts or all of the joint root

_____ e. A line through the length of a weld, perpendicular to the corss-section at its center of gravity

_____ f. A nonmetallic product resulting from the mutual dissolution of flux and nonmetallic impurities in some welding and brazing processes

_____ g. The weight of material deposited in a unit of time

_____ h. Any procedure or device for protecting an in-process weld from atmospheric contamination

_____ i. The final bead or beads needed to complete a welded joint

_____ j. Any procedure or device for protecting an in-process weld from atmospheric contamination

Objective 2

Select true statements concerning advantages of SMAW by placing an "X" in the blanks beside the true statements.

_____ a. Equipment is relatively expensive.

_____ b. Equipment is portable because the welding machines can be powered with gasoline or diesel powered engines.

_____ c. Applications are relatively simple and can be adapted to many job requirements.

_____ d. SMAW is well suited for maintenance and repair work in small shops, on farms, and in garages.

Written Test

Objective 3

Complete statements concerning the principles of SMAW by circling the answer that best completes each of the following statements.

a. An electric arc is struck between a grounded base metal and a **(flux-covered) (base)** electrode held in a holder and manipulated by hand.

b. The heat of the arc melts the base metal and the metal in the electrode so that the two **(fuse) (stick)** together to create the weld.

c. Flux contained on the electrode covering is also **(fused or vented) (melted or vaporized)** to provide shielding that protects the weld from contaminants in the air, hence the name Shielded Metal Arc Welding and Carbon Arc Cutting—Air.

Objective 4

Solve problems concerning the relationship of arc, base metal, electrode, and flux by circling the number of the item that best solves each of the following scenarios.

a. A fellow student is trying to define what happens when an electrode is held about 1/8" away from the base metal. The phrase he is looking for is:

(1) Electrode activation
(2) Spark
(3) Arc stream

b. Another fellow student is trying to explain what happens to the molten pool or crater in the welding process. The student says that it hardens, but more accurately:

(1) The crater tends to move away from the arc and cool and solidify.
(2) The crater stays right beneath the arc to afford pinpoint welding accuracy.
(3) The crater cools as the arc moves along.

c. Your instructor asks you to identify the covering that forms over a weld because of flux from the covered electrode. The covering is called:

(1) Kerf
(2) Slag
(3) Contaminant

Objective 5

Differentiate between elements of flux-covered electrode functions by selecting the best answer to the following conditions.

a. The part of the electrode that melts in the arc stream to provide filler metal is:

(1) The core of metal wire
(2) The baked-on chemical covering
(3) The flux

70

b. Another part of the electrode that melts in the arc stream helps to stabilize the arc and provide a shield around the arc, but it also:

(1) Assures 100 percent deposition
(2) Provides a slag covering to protect the weld
(3) Helps the weld cool faster

Objective 6

Select true statements concerning benefits of learning SMAW by placing an "X" in the blanks next to the true statements.

_____ a. SMAW introduces a beginner to the basics of all welding processes.

_____ b. SMAW acquaints the beginner with the welding machines and electrical accessories used in other arc welding processes.

_____ c. SMAW introduces the beginner to the world of electrodes and their relationship to metal thicknesses, welding speeds, and amperage requirements.

_____ d. SMAW acquaints the beginner with the basic concepts of shielding and how shielding improves and protects a weld.

_____ e. SMAW helps the student develop the mental attitudes required to work with other arc welding processes.

_____ f. SMAW gives the beginner an added welding skill that will add versatility to job-getting resumés.

Objective 7

Match welding machines with their electrical characteristics.

1. AC	3. DC	5. DCEP
2. Basic circuit	4. DCEN	6. Polarity

_____ a. This is the direction that current flows through a basic welding circuit, and is expressed as negative or positive in relation to DC current.

_____ b. This is current that flows in only one direction.

_____ c. This is produced by a negative electrode and a positive workpiece that causes the current to flow from the electrode to the workpiece.

_____ d. Current must travel in a complete loop from the power supply to the arc and back to the power supply, and the circuit must be grounded.

_____ e. This is current that alternates from one direction to another 60 times per second, and is expressed as 60 Hertz.

_____ f. This is produced by a positive electrode and a negative workpiece that causes the current to flow from the workpiece to the electrode.

Objective 8

Match welding machine performance characteristics with their applications.

1. AC or DC transformer-rectifier
2. AC transformer
3. DC generator
4. Duty cycle
5. Inverter

____ a. In these machines, current varies with the speed the armature turns, polarity changes may be made by flipping a switch or reversing weld connections, and some of these machines are powered with AC motors while others are powered with gas or diesel engines.

____ b. These machines change high-voltage, low-amperage AC to low-voltage, high-amperage AC or DC, and these machines are ideal for adjustment to different materials and welding positions.

____ c. Sizes of welding machines are rated in accordance with their amperage capacity at 60–100 percent of safe use for a given period.

____ d. These machines change high-voltage, low-amperage AC to low-voltage, high-amperage AC in machines that usually have a 220/240 volt input current.

____ e. Utilizes solid-state components to change the incoming 60 Hz power to a higher frequency, nominally 18 to 100 kHz. Changing the frequency results in greatly reduced size and weight of the transformer. Can be used with all processes.

Objective 9

Complete statements concerning basic SMAW accessories and their purposes by circling the correct answers.

a. Cables are insulated **(copper) (aluminum)**, extra-flexible leads that carry the current from the power sources to the **(rest of the system) (electrode)**, and they vary in size or diameter according to machine capacity and length requirements..

b. Clamps are used to fasten the cables to a workpiece or table where the workpiece is positioned so that the welding circuit will be **(DCEP) (completed)** and some operate with spring pressure while others are **(welded on) (magnetic)**.

c. Electrode holders are hand-held clamping devices that hold the electrode during the welding process; they should be selected according to the machine's **(maximum) (minimum)** output rating, and they should be well insulated, lightweight to keep a welder from tiring, and sturdy enough to stand up under **(exposure to rain) (continued use)**.

72

Objective 10

Complete statements concerning AWS electrode classifications for mild steel and low alloy electrodes by circling the material that best completes each statement.

a. The prefix "E" designates an **(electrode) (electric arc welding electrode)**.

b. The first two digits of 4-digit numbers and the first three digits of 5-digit numbers indicate **(minimum) (maximum)** tensile strength.

c. The next-to-last digit indicates **(type of weld it is suitable for) (position)**.

d. The last digit (0 through 8) together with the next-to-last digit indicate the type of covering and current to be used, and **(high-carbon steel) (mild steel)** electrodes are also classified as fast-freeze, fill-freeze, fast-fill, and low hydrogen.

e. The last letter and digit indicate the approximate **(amount of copper) (alloy)** in the deposit.

f. In addition to the AWS classification system, electrodes are also classified according to **(length and diameter expressed in feet and inches) (diameter expressed in fractions of an inch)**.

Objective 11

Differentiate between stainless steel and other alloy electrodes by placing an "S" beside the definition of stainless steel electrodes and an "O" next to the definition of other alloy electrodes.

_____ a. These have chemical symbols which precede the digits.

_____ b. These are numbered to match specific types of metals.

Objective 12

Complete statements concerning basic elements of arc welding and their importance by circling the material that best completes each statement.

a. Electrode selection must be related to both the type and thickness of a base metal, and one rule of thumb is that electrode diameter should not exceed the thickness **(of the base metal) (of the base metal by more than 1/8")**.

b. Welding speed is the greatest factor in reducing welding costs, and one rule of thumb is to use the **(largest) (smallest)** allowable electrode at the **(highest) (lowest)** acceptable amperage.

c. In welding positions for vertical, overhead, and horizontal butt welds, the maximum size for an E6010 or E6011 is 3/16", and for these same positions with a low-hydrogen electrode, the maximum size is **(5/32") (also 3/16")**.

d. For joint preparation a narrow V-groove in a butt joint will usually prevent the use of a large electrode on **(the first pass) (finish passes)** problems.

e. With fit-up, backup strips are permitted **(with most codes) (anytime)**.

f. Machine capacity is important because amperage ratings on some welding machines may not be large enough to properly handle **(low hydrogen) (large electrodes)**.

g. Amp settings are always determined by electrode selection and welding position, and the rule of thumb is to turn your amps down when welding vertical **(up) (down)** and to turn your amps up when welding vertical **(down) (up)**.

h. The rule of thumb for voltage changes between the electrode and the base metal is that a **(long) (short)** arc increases voltage and a **(short) (long)** arc decreases voltage.

i. Polarity is determined by electrode selection, and correct polarity is extremely important in **(DC) (AC)** electric arc welding processes.

Objective 13

Select the five esstentials of a good weld from the following list.

_____ a. Correct electrode angle

_____ b. Correct ventilation in the workplace

_____ c. Correct travel speed

_____ d. Correct arc length or voltage

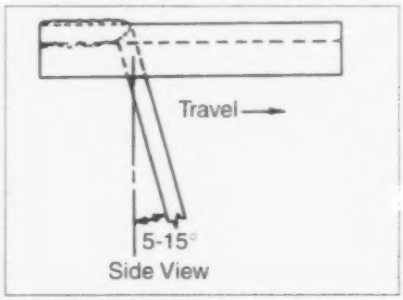
_____ e. Correct welding helmet and hard hat

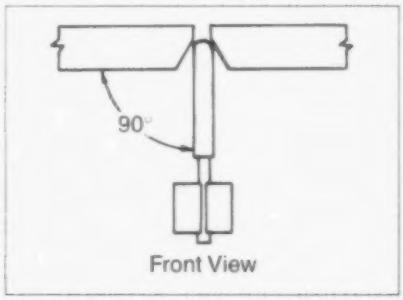
_____ f. Correct current

_____ g. Correct electrode size

Objective 14

Differentiate between electrode angles. Place a "T" below the illustration of a travel angle, and a "W" below the illustration of a work angle.

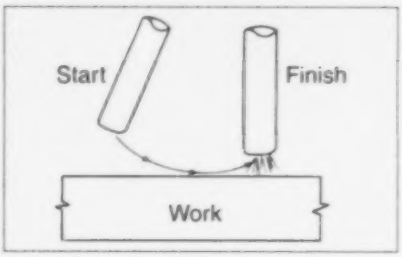


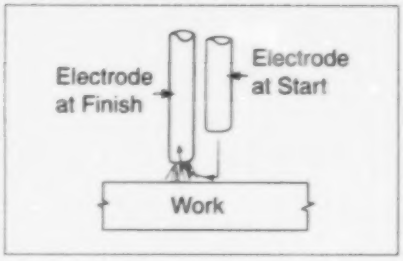


a._____ b. _____

Objective 15

Differentiate between SMAW starting techniques. Place an "S" below the illustration of the scratch method and a "T" below the illustration of the tap method.





a. _____ b. _____

Objective 16

Complete statements concerning techniques for controlling arc gap by circling the material that best completes each statement.

a. Arc gap should usually be slightly **(more) (less)** than the diameter of the electrode.

b. Too much gap can usually be identified by a **(crackling) (hissing)** sound as opposed to a **(crackling) (hissing)** sound.

c. Too much gap can be spotted visually because it causes excess spatter and poor (adhesion) (penetration).

d. Too much gap will cause filler metal to melt off in large wobbly drops, and slag will **(not form properly) (be difficult to remove)**.

e. With **(too little) (too much)** gap, the arc will not start, or the electrode may freeze to the weld puddle and stick there.

Objective 17

Complete statements concerning techniques for using electrode angles by circling the material that best completes each statement.

a. The electrode work angle refers to the electrode's angular relationship to:

(1) The direction of travel
(2) The worktable
(3) The base metal

b. The electrode travel angle refers to the electrode's angular relationship to:

(1) The direction in which welding moves
(2) The movements a welder uses to maintain position
(3) The distance of a weld

c. A rule of thumb for maintaining a proper work angle is to keep the electrode:

(1) At a 45° angle from the base metal
(2) At a 90° angle from the base metal
(3) At any angle that is comfortable

Objective 18

Match bead running techniques with their procedures.

1. Box weave
2. Circular motion
3. Drag
4. Padding
5. Side-to-side weave
6. Stringer bead
7. Triangular weave
8. Whip and pause
9. Whipping
10. Whipping with slight weave in crater

_____ a. Used with fill-freeze and low-hydrogen electrodes to make the first pass on vertical fillet and V-groove butt welds because it provides a larger weld than a side-to-side weave

_____ b. Used with high-deposit, fast-fill electrodes and consists of lightly dragging the electrode tip along the base metal to force the molten filler metal uniformly out from under the electrode tip which in turn provides good penetration

_____ c. Can be used with fast-freeze electrodes to make the first pass on vertical fillet and V-groove butt welds

_____ d. Used with all types of electrodes to make fill passes on vertical fillet and V-groove butt welds, and also sometimes used with fill-freeze and low-hydrogen electrodes to make the first pass on these joints

_____ e. Used with fast-freeze electrodes to make stringer beads in all positions and on all types of joints, and consists of maintaining a short arc when in the crater and a long arc as the electrode is drawn out of the crater so the molten pool will stay small and allow the filler metal to freeze quickly so the metal does not spill through the joint.

_____ f. Used with all types of electrodes to make the fill pass on vertical fillet and V-groove butt welds, and is similar to the side-to-side weave, but with a distinct pause and slight upward motion at each edge of the weld to assure complete crater fill-up and eliminate undercutting.

_____ g. Used with all types of electrodes to make overhead welds

_____ h. A single, straight bead used with certain types of electrodes, and consists of a drag or whipping motion used in all welding positions

_____ i. A technique for laying down a bead by following the line of welding with a slight whipping action back from a weld puddle, a brief pause, and thena slighter whipping action back to the edge of the weld puddle to continue the bead.

_____ j. Used with all types of electrodes to build up metal surfaces with one or more layers of weld beads, and can be used on either fillet or curved surfaces as overlapping straight beads or overlapping weave beads

Objective 19

Select true statements concerning the technique for stopping and restarting an arc by placing an "X" in the blanks next to the true statements.

_____ a. Anticipate the point where the rod is going to be used up or where welding will stop.

_____ b. Stop the forward motion of the electrode.

_____ c. Quickly withdraw the electrode to break the arc.

_____ d. Chip the slag off the end of the weld about 1/4″ to 1/2″ back.

_____ e. Restart the arc about 1/2″ in front of the forward end of the crater.

_____ f. Move the electrode slowly back to the back crown of the crater and immediately resume welding in the direction of travel.

_____ g. If the stop/restart procedure is properly executed, any marks left by restarting the arc ahead of the crater will be covered as the weld bead is continued.

Objective 20

Complete statements concerning techniques for filling a crater at the end of a weld by circling the material that best completes each statement.

a. Option 1:

(1) Just before the bead reaches the end of the plate, draw the electrode **(slowly up and slightly backward) (quickly up and slightly forward)** over the completed weld.

(2) Make sure the motion is **(slow) (fast)** enough to allow the crater to fill and that the **(backward) (forward)** motion is far enough that the crater remains on top of the bead about 1/4″ to 1/2″ back from the end of the weld.

b. Option 2:

(1) Break the arc about 1″ to 2″ from the end of the weld by quickly shortening the arc and pulling it **(sideways) (straight up)** out of the crater.

(2) Chip and **(grind) (remove slag from)** the end of the bead.

(3) Move to the end of the plate, restart the arc, and weld **(back toward) (over)** the bead.

(4) Incline the electrode about **(90° from the base metal) (60° in the direction of travel)**.

(5) Weld back over the crater and stop the arc by pulling up and slightly **(forward) (backward)** as the two beads run together and the crater forms properly on top of the bead.

Objective 21

Select guidelines for using feathered edges for tie-ins by circling the best answer for each of the following:

a. A tie-in point should always be chipped and brushed

(1) Only from a tack weld
(2) Only when restarting a bead
(3) When restarting a bead or when starting from a tack weld

b. Another case where a feathered edge should be used is:

(1) Anytime a bead is restarted
(2) When a weld deposit is too large to make a normal tie-in
(3) To end a weld properly

c. Feathering requires a sloping, sharp edge at the ed of a bead, and this is accomplished with:

(1) A hand grinder
(2) A file
(3) A chipping hammer

Objective 22

Differentiate between basic steps in joint preparation by placing a "B" beside the definition for beveling and a "G" beside the definition for grinding.

_____ a. This requires putting angles on pieces of material so that when they are joined, the weld will get good penetration below the surface of the base metal.

_____ b. This requires the use of an abrasive device, usually portable, to remove metal or slag from the weld area.

Objective 23

Match good and bad welds with their characteristics.

1. Current low
2. Current high
3. Current, voltage, and speed normal
4. Speed fast
5. Speed slow
6. Voltage high
7. Voltage low

____ a. Poor penetration and humped bead

____ b. Excessive heat and weld metal reinforcement leading to unnecessary distortion of joint

____ c. Excessive spatter and undercutting of weld joints

____ d. Irregular bead, poor penetration, undercut, and not enough weld metal in joint, causing a weak joint

____ e. Poor penetration, slow progress, excessive piling of weld metal, and slag inclusion

____ f. Poor penetration with flat bead, weld zone not shielded

____ g. Smooth well-formed bead with no undercutting, overlapping, or piling of slag

Objective 24

Select causes of and remedies for arc blow by circling the information that best completes each statement.

a. Arc blow is caused by:

(1) Magnetic forces present in DC
(2) Contaminants in the air
(3) Out of position welding

b. Arc blow can also cause:

(1) The electrode to freeze the puddle
(2) Poor tie-ins
(3) The arc to blow wildly and spatter badly

c. One remedy for controlling arc blow is to reduce current or switch polarity, but other remedies include:

(1) Changing welding cables and holder
(2) Hanging current to AC, changing ground clamp location, and maintaining a short arc
(3) Increasing amperage and speed

Objective 25

Select causes of and remedies for pinholes and porosity by circling the information that best completes each statement.

a. Both pinholes and porosity can be caused when:

(1) Arc length is too short
(2) Travel speed is too slow
(3) Arc length is too long and travel speed is too fast

b. Pinholes and porosity can also be caused by faulty electrodes, incorrect polarity, or:

(1) Bad joint design
(2) Bad flux
(3) Surface conditions of the base metal

c. Remedies for pinholes and porosity include:

(1) Increasing welding speed and turning up amperage
(2) Using a shorter arc length and keeping the puddle molten for a longer period
(3) Switching polarity and changing to a small electrode

Objective 26

Select causes of and remedies for undercutting by circling the information that best completes each statement.

a. Undercutting is usually caused when:

(1) Surface metals are not properly prepared
(2) Arc length is too long or current is too high
(3) Polarity is wrong

b. Undercutting can also be caused by:

(1) Too large an electrode
(2) A welding speed that is too slow
(3) Improper manipulation of rod angle or a welding speed that is too fast

c. The most common remedies for undercutting would be to:

(1) Try a larger electrode or faster travel speed
(2) Lengthen the arc length and increase current
(3) Reduce the current and shorten the arc length

Objective 27

Select causes of and remedies for weld spatter by circling the information that best completes each statement.

a. Weld spatter is caused by

(1) Bad electrode angle
(2) Too much current and too long an arc length
(3) Too small electrode

b. Weld spatter can be remedied by:

(1) Reducing current and shortening arc length
(2) Using a larger electrode
(3) Changing electrode work angle

Objective 28

Select causes of and remedies for incomplete penetration by circling the information that best completes each statement.

a. Incomplete penetration can be caused by insufficient welding current, too large an electrode, or too fast a welding speed, but another cause could be:

(1) Surface conditions of base metal
(2) Faulty joint design
(3) Bad electrode travel angle

b. One remedy for incomplete penetration is to:

(1) Decrease welding current
(2) Increase welding speed
(3) Check the joint carefully

c. Other remedies for incomplete penetration include:

(1) Increasing weld current, reducing welding speed, and using a smaller diameter electrode
(2) Reducing weld current, increasing welding speed, and using a larger diameter electrode
(3) Moving the ground to a new location on the workpiece and increasing weld current

Objective 29

Select causes of and remedies for slag inclusion by circling the information that best completes each statement.

a. Slag inclusion can be caused by:

(1) Improper bevel angle
(2) Sharp, V-shaped recess in the joint design
(3) Too high a welding current

b. Slag inclusion may also result from:

(1) High flow rate of molten metal of a weld current too low
(2) Too small a diameter electrode
(3) Wrong polarity

c. One remedy for slag inclusion is to use a higher welding current, but eradicating slag inclusion sometimes requires:

(1) Redesigning the joint
(2) Grinding
(3) Preheating and increasing the size of the weld area

Objective 30

Select causes of and remedies for excessive weld reinforcement by circling the information that best completes each statement.

a. Weld reinforcement can be caused by poor electrode movement, but it is usually caused by:

(1) Arc blow
(2) The wrong electrode size or too slow a travel speed
(3) Out of position welding

b. Aside from maintaining good electrode movement, the remedies for excessive weld reinforcement include:

(1) Increasing amperage and slowing travel speed
(2) Choosing the correct electrode and increasing travel speed
(3) Reversing polarity and choosing a larger electrode

Objective 31

Complete statements concerning electrode drying ovens by circling the material that best completes each statement.

a. Because moisture can change the **(electrical) (chemical)** composition of some flux-covered electrodes, certain electrodes need to be stored in drying ovens and sometimes reconditioned or rebaked in **(a drying oven) (an industrial kiln)**.

b. Reconditioning or rebaking times should be as recommended by the **(drying oven manufacturer) (electrode manufacturer)** in relation to electrode type and relative humidity of the storage area.

*Permission to duplicate this test is granted.

Answers to Written Test

Objective 1

a.	8	d.	2	g.	1
b.	4	e.	7	h.	5
c.	9	f.	3	i.	6

Objective 2

b, c, d

Objective 3

a. Flux-covered
b. Fuse
c. Melted or vaporized

Objective 4

a. 3
b. 1
c. 2

Objective 5

a. 1
b. 2

Objective 6

b, c, d, f

Objective 7

a.	3	d.	1
b.	4	e.	5
c.	6	f.	2

Objective 8

a. 3
b. 1
c. 2
d. 4

Objective 9

a. Copper, electrode
b. Completed, magnetic
c. Maximum, continued use

Objective 10

a. Electric arc welding electrode
b. Minimum
c. Position
d. Mild steel
e. Alloy
f. Diameter expressed in fractions of an inch

Objective 11

a. O
b. S

Objective 12

a. Of the base metal
b. Largest, highest
c. 5/32″

d. The first pass
e. With most codes
f. Large electrodes
g. Up, down
h. Long, short
i. DC

Objective 13

a, c, d, f, g

Objective 14

a. T
b. W

Objective 15

a. S
b. T

Objective 16

a. Less
b. Hissing, crackling
c. Penetration
d. Be difficult to remove
e. Too little

Objective 17

a. 3
b. 1
c. 2

Objective 18

a. 4	d. 1	g. 5
b. 8	e. 9	j. 3
c. 1	f. 2	i. 7

Objective 19

a, b, d, e, g

Objective 20

a. 1. Slowly up and slightly backward
2. Slow, backward
b. 1. Sideways
2. Remove slag from
3. Back toward
4. 60° in the direction of travel
5. Backward

Objective 21

a. 3
b. 2
c. 1

Objective 22

a. B
b. G

84

Objective 23

a. 4
b. 1
c. 6
e. 3
e. 7
f. 5
g. 2

Objective 24

a. 1
b. 3
c. 2

Objective 25

a. 3
b. 3
c. 2

Objective 26

a. 2
b. 3
c. 3

Objective 27

a. 2
b. 1

Objective 28

a. 2
b. 3
c. 1

Objective 29

a. 2
b. 1
c. 3

Objective 30

a. 2
b. 2

Objective 31

a. Chemical, a drying oven
b. Drying oven manufacturer

Mild Steel Electrode Groups

AWS#	Group	Characteristics	Applications
E6010	Fast-Freeze	Produce a deep, penetrating arc that leaves a fast-freezing flat bead with little slag	All types of welding in all positions, and primarily used with DC+
E6011	Fast-Freeze	Produce a deep, penetrating arc that leaves a fast-freezing flat bead with little slag	All types of welding in all positions, and primarily used with AC
E6012 E6013 E7014	Fill-Freeze	Produce a moderate arc and leaves beads with distinct, even ripples with complete slag coverage	Can be used in all positions, but preferred for overhead and vertical welding; these are commonly straight-polarity electrodes though sometimes used with AC
E6027 E7024	Fast-Fill	Heavily coated with iron powder to produce a soft arc that provides a fast deposit rate and leaves a smooth bead with heavy slag	Frequently used in production welding where work can be positioned for downhand welding
E7018	Low Hydrogen	Little hydrogen in coating, but must be used soon after opening or stored in a drying oven to avoid moisture	Can be used in all positions, and are first choice for welding problem steels because of outstanding crack resistance and elimination of porosity

Selection Data for Mild Steel Electrodes

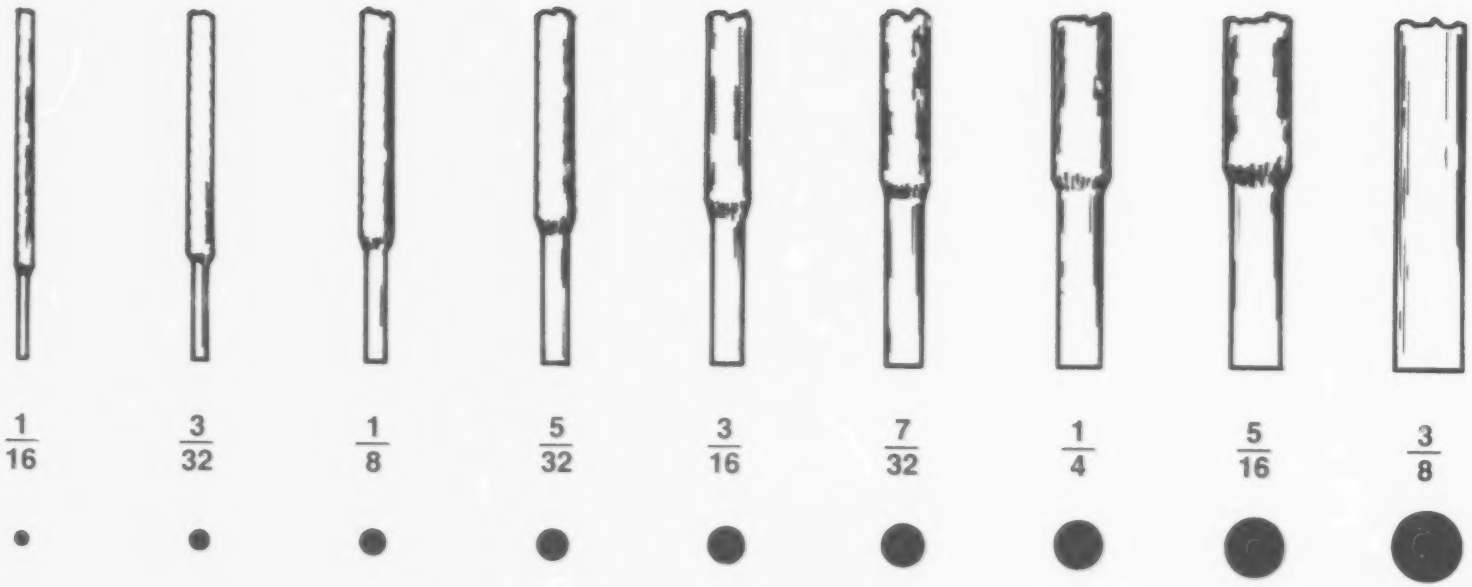
AWS CLASS	ELECTRODE POLARITY (+) = POSITIVE (−) = NEGATIVE	SIZES AND CURRENT RANGES (Amps.)							
		5/64" SIZE	3/32" SIZE	1/8" SIZE	5/32" SIZE	3/16" SIZE	7/32" SIZE	1/4" SIZE	5/16" SIZE
MILD STEEL									
E6010	DC(+)		40-75	75-130	90-175	140-225	200-275	220-325	240-400
E6012	DC(−)			80-135	110-180	155-250	225-295	245-325	
	AC			90-150	120-200	170-275	250-325	275-360	
E6011	AC		50-85	75-120	90-160	120-200	150-260	190-300	
	DC(+)		40-75	70-110	80-145	110-180	135-235	170-270	
E6011	AC			80-130	120-160				
	DC(±)			70-120	110-150				
E6013	AC	50-80	75-105	110-150	160-200	205-260			
	DC(±)	45-75	70-95	100-135	145-180	190-235			
E7014	AC			110-160	150-225	200-260	260-340	280-425	
	DC(−)			100-145	135-200	180-235	235-305	260-380	
E6013	AC			100-150	150-200	200-260			
	DC(±)			90-135	135-180	180-235			
E6011	AC		40-90	60-120	115-150				
	DC(+)		40-80	55-110	105-135				
E7024	AC		65-102	115-175	180-240	240-300	300-380	340-440	
	DC(±)		60-110	100-160	160-215	220-280	270-340	320-400	
E6027	AC				190-240	250-300	300-380	350-450	
	DC(±)				175-215	230-270	270-340	315-405	
E7024	AC			115-175	180-240	240-315	300380	350-450	380-600
	DC(±)			100-160	160-215	215-285	270-340	315-405	360-600
E7018	DC(+)			90-150	120-190	170-280	210-330	290-430	375-500
	AC			110-170	135-225	200-300	260-380	325-440	400-530
E7018-1	DC(+)			95-160	120-190	180-270	250-330	300-400	
	AC			100-170	135-225	210-290	270-370	325-420	
7018 (white numbers)	DC(+)			110-160	130-200	180-270	250-330	300-400	
	AC			120-170	140-230	210-290	270-370	325-420	
E7028	AC				180-270	240-330	275-410	360-520	
	DC(+)				170-240	210-300	260-380		

Selection Data for Stainless Steel and Other Alloy Electrodes

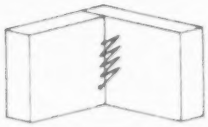
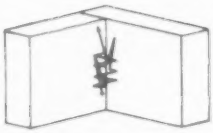
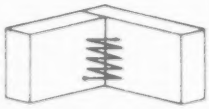
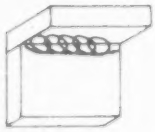
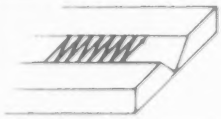
AWS CLASS	ELECTRODE POLARITY (+) = POSITIVE (−) = NEGATIVE	SIZES AND CURRENT RANGES (Amps.)							
		5/64" SIZE	3/32" SIZE	1/8" SIZE	5/32" SIZE	3/16" SIZE	7/32" SIZE	1/4" SIZE	5/16" SIZE
STAINLESS STEEL									
E308-15	DC(+)		30-70	50-100	75-130	95-165		150-225	
E308-16	DC(+); AC	20-45	30-60	55-95	80-135	115-185		200-275	
E308L-16	DC(+); AC		30-65	55-100	80-140	115-190			
E309-16	DC(+); AC		30-60	55-95	80-135	115-185		200-275	
E310-15	DC(+)		30-70	45-95	80-135	100-165			
E310-16	DC(±); AC		30-65	55-100	80-140	120-185		200-275	
E316L-16	DC(+); AC		30-65	55-100	80-140	115-190			
E347-15	DC(+)		30-70	50-100	75-130	95-165			
E347-16	DC(+); AC		30-60	55-95	80-135	115-185			
BRONZE AND ALUMINUM									
E-CuSn-C	DC(+)			50-125	70-170	90-220			
Al-43	DC(+)		20-55	45-125	60-170	85-235			

CAST IRON					
		1/8" SIZE	5/32" SIZE	3/16" SIZE	1/4" SIZE
ESt	DC(+); AC	80-100			
Eni-CI	DC(±)	60-110	100-135		
	AC	65-120	110-150		

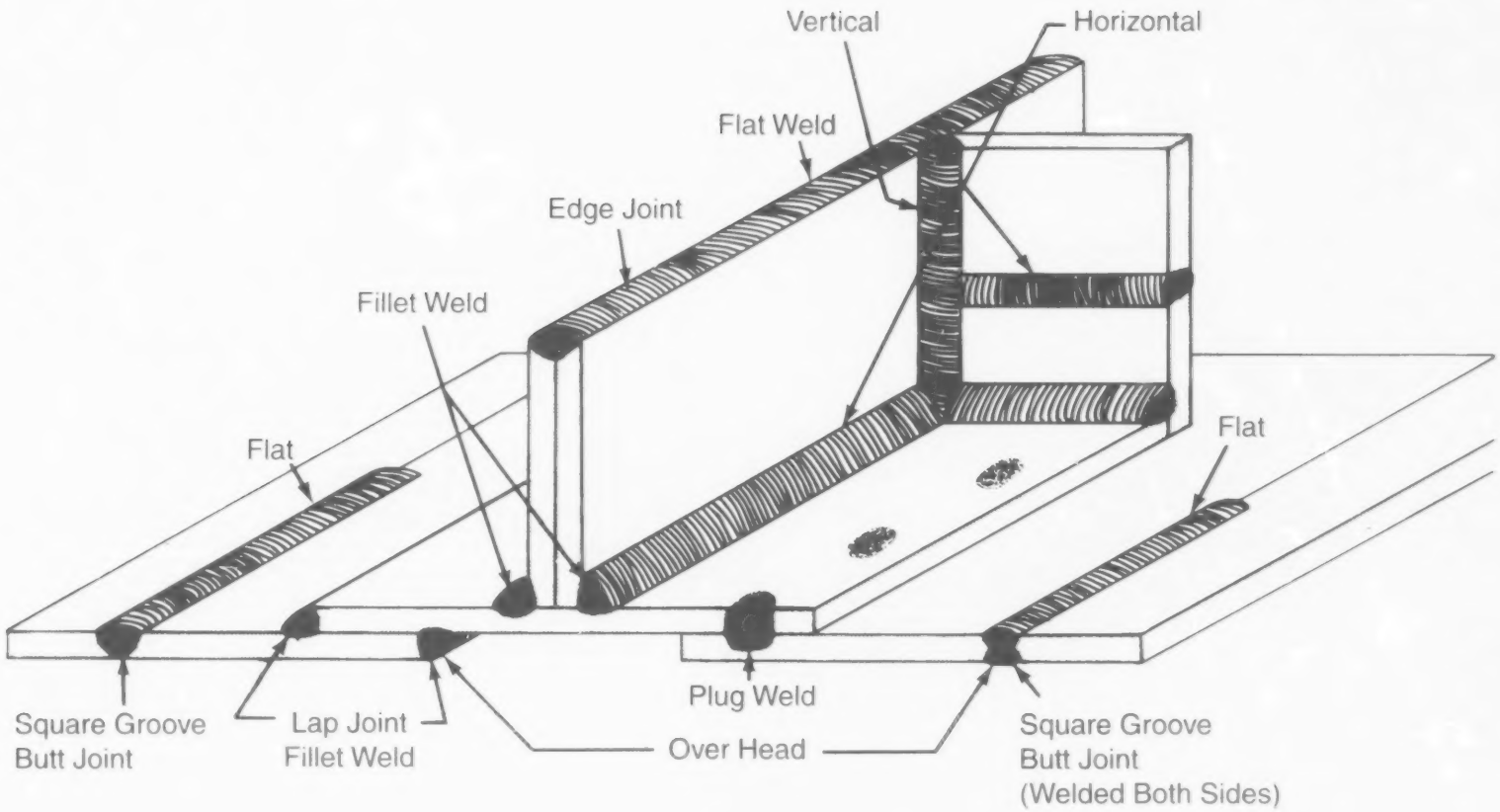
Electrode Sizes
(Actual Sizes)



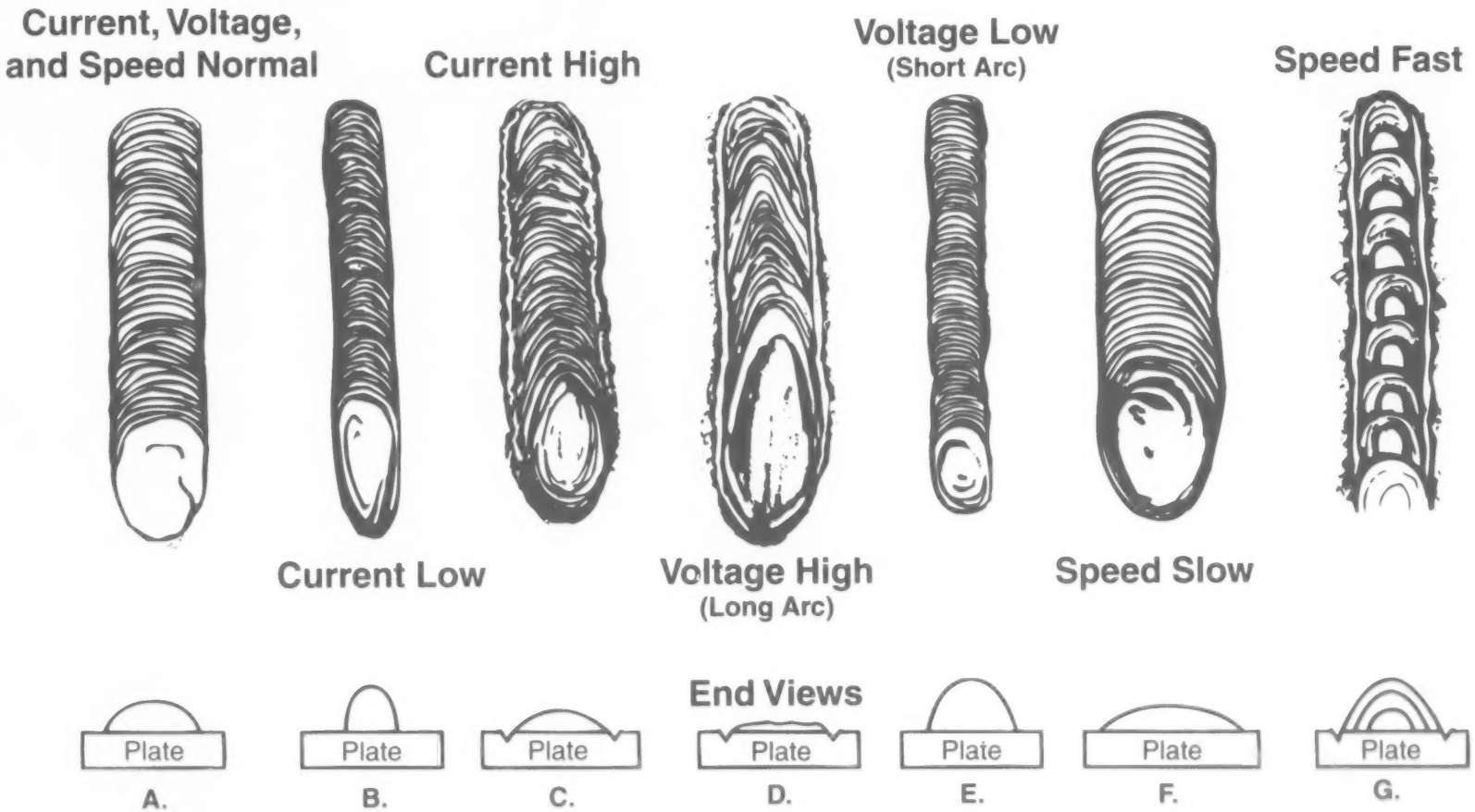
Basic Motions for Electrode Manipulation

Motion	Illustration	Typical Uses
Straight whipping motion		Used with fast-fill electrodes to make stringer beads in all positions and on all types of joints
Whipping motion with slight weave in crater		Can be used with fast-fill electrodes on the first pass of vertical fillets and V-butts
Vertical side-to-side weave		Used with all types of electrodes to make fill passes on vertical fillets and V-butts; sometimes used with fill-freeze and low-hydrogen electrodes for first pass on fillets and V-butts
Triangular weave		Used with fill-freeze and low-hydrogen electrodes to make first pass on vertical fillets and V-butts
Box weave		Used with all types of electrodes to make fill passes on vertical fillets and V-butts, and has a distinct pause and slight upward motion at each edge of the weld
Circular motion		Used with all types of electrodes to make overhead welds, and is sometimes used with a slight whip after each circular motion in the crater
Flat side-to-side weave		Used with all electrodes on wide V-grooves in the flat position

Typical Welded Joints and Positions



Good and Bad Welds



Unit Contents

Teacher Page

Teacher Components

Suggested Activities 3–3

Written Test 3–7

Answers to Written Test 3–11

Student Page

Student Components

Learning Activities Sheet 3–3

Objective Sheet 3–5

Information Sheet 3–7

Student Supplement

1—Hardfacing Electrode Selection 3–11

*Job Sheets

1—Build a Pad on Mild Steel With a Hardfacing Electrode 153
2—Prepare and Hardface Simulated Bucket Teeth 157

*The Job Sheets are located in the Student Workbook.

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Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.
- Discuss and demonstrate the job sheets. Make sure all required tools, equipment, and materials are available. Review with students the criteria for evaluation of these activities and the rating scale that will be used to indicate job performance.

Suggested Activities

Teaching Suggestions

- Discuss area shops or manufacturers who use hardfacing in their equipment maintenance programs. Invite owners or supervisors to talk to the class about the value hardfacing skills can add to a welder's employability.

- Use Objectives 1 through 4 to emphasize the versatility of manual hardfacing and point out that hardfacing is highly portable for field word on farms and other agricultural activities.

- When students study Objective 5 about types of wear, try to have some examples of metal-to-metal wear, severe impact, corrosion, or as many examples as you can find that are readily available.

- When you talk about distortion control as part of Objective 6, it would be advantageous to refer students to the distortion control elements in Unit 5 "Basic Metals and Metallurgy" in MAVCC's *Fundamentals of Welding*.

- When discussing hardfacing ventilation safety in Objective 7, encourage students to wear a filter mask under their welding helmet when working with hardfacing electrodes.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.

- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.

- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

  Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

Sample A

4—**Skilled**—Can perform job with no additional training.
3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
1—**Unskilled**—Is familiar with process, but is unable to perform job.
0—**No exposure**—No information or practice provided during training program.

Sample B

Yes—Can perform job with no additional training.
No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- *HARDFACING GUIDE, Product and Procedure Selection.* Cleveland, OH: The Lincoln Electric Company.
- *WEARSHIELD® AND LINCORE®, Hardfacing Stick Electrodes and Wires.* Cleveland, OH: The Lincoln Electric Company.

  Note: The reference for the HARDFACING GUIDELINE is C7.710 6/96 and is available from the Lincoln Electric Company on line at: lincolnelectric.com (follow the screen prompts) or telephone Lincoln Electric at 216-481-8100. The Hardfacing Stick and Electrode Wires reference is C7.10 8/97 and is also available at the Lincoln web address or telephone. Both products are highly recommended for any program that is planning to pursue extended training in hardfacing.

- *Product Selection Guide Build-up and Hardfacing Electrodes and Wires.* Bowling Green, KY 42101: Stoody, 2001.
- *The Rebuilding and Hardfacing of Agricultural Implements* (Guidebook Section 3). Bowling Green, KY 42101: Stoody, 1998.

  Note: The product selection guide and the guidebook for rebuilding and hardfacing agricultural implements are both available from Stoody at 1-800-227-9333, or at www.stoody.com on the web.

Electronic Media

- Welding: Make It Happen (23 minutes)

  Note: This video effectively portrays the many ways welding touches our everyday lives. An excellent choice for general presentations to parents, career counselors, and vo-tech candidates.

- Welding as a Career (15 minutes)

  Note: Promoted are student opportunities in welding as a career and educational opportunities at a typical technical school. Portrayed are a range of welding career options and their benefits, such as possessing a productive skill, interesting work, good pay, and growth opportunities.

- Welding: So Hot, It's Cool (11 minutes)

  Note: The American Welding Society's career education video; provides students with information on career possibilities in welding. Designed for kids 13-15.

  Order the preceding videos from the American Welding Society at www.aws.org, or call (800) 334-9353.

Written Test

Name _____

Date _____ Score_____

Objective 1

Match the terms with their definitions.

1. Build-up
2. Buttering
3. Hardfacing
4. Base metal

_____ a. The type of metal in a part selected for hardfacing and the primary consideration for selecting build-up material for hardfacing

_____ b. Sometimes a preliminary step in hardfacing because it is the process that dilutes the carbon and alloy content of base metal before build-up begins

_____ c. The step in hardfacing where selected weld metal is applied in a layer or layers on a part selected for hardfacing

_____ d. The final layer of metal deposited after build-up in the hardfacing process

Objective 2

Complete statements about the benefits of hardfacing by circling the answer(s) that best completes each statement.

a. Hardfacing is a (**low-cost, medium cost**) method of depositing wear-resistant surfaces onto metal components to extend their service life and avoid high-cost (**repairs, replacement parts**).

b. Although hardfacing is primarily used to restore (**worn, old**) parts to a serviceable condition, hardfacing is also applied to (**new, replacement**) components before they are placed into service to extend service life.

Objective 3

Select true statements about welding methods used for hardfacing by placing an "X" in the blanks next to the true statements.

_____ a. Semiautomatic welding uses wire feeders and self-shielded, flux-cored electrodes for depositions rates greater than those achieved with manual welding.

_____ b. Automatic welding requires a minimal initial setup, and provides the highest deposition rate for maximum productivity.

_____ c. Manual electrode hardfacing is recommended for irregular shapes, out-of-position welding, low-volume applications, and many small parts.

Written Test

Objective 4

Complete statements about advantages and limitations of manual electrode hardfacing by circling the correct answers that best complete the following statements.

a. The greatest advantage of manual electrode hardfacing is its (**low cost, versatility**) because it can handle nearly any shape or contour.

b. Another advantage of manual hardfacing is that it can be used on small or large parts in all positions although positioning for (**vertical, downhand**) welding is recommended.

c. One limitation with manual hardfacing is that labor costs are relatively high because deposition rates are (**lower, higher**) than with mechanized processes.

d. Another limitation with manual hardfacing is the prospect that (**machine error, human error**) could result in poor welding quality or a rough surface.

Objective 5

Match types of wear with their characteristics.

1. Corrosion
2. Abrasion plus impact
3. Severe abrasion
4. Metal-to-earth abrasion
5. Metal-to-metal
6. Combination wear
7. Severe impact

_____ a. Wear from steel parts rolling or sliding against each other with little or no lubrication, conditions in sprockets and gear teeth

_____ b. Wear from severe pounding which tends to squash, gouge, and check the surface, conditions found in much construction equipment

_____ c. Wear from gritty materials accompanied by heaving pounding which tends to chip or crack as well as grind away the surface, conditions found in buckets and dump blades

_____ d. Wear from gritty materials which grind or erode the surface and often accompanied by heavy compression or moderate impact, conditions found in crusher rolls and conveyor screws

_____ e. Wear from earth-like materials like sand, grit and pebbles accompanied by moderate impact from pounding, conditions found in scraper blades and paddles

_____ f. Wear caused by chemical exposure like conditions found in valve faces and seats

_____ g. The combination of two or more of the previously listed phenomena; combination wear in most or at least many cases is the effective wear on a component

Objective 6

Complete guidelines for applying weld deposits by circling the answer that best completes each of the following statements.

a. All hardfacing should start with (**cleaning, pressure washing**) to remove rust, dirt, grease, oil and other contaminants from the surfaces to be built up and hardfaced.

b. Surfaces to be hardfaced require preparation especially if badly cracked or deformed, and the preparation may require (**machine, hand**) grinding or carbon arc gouging.

c. Avoid (**fast-paced, excessive**) build-up of hardfacing deposits or they may crack and break off rapidly in service and in cases where thick deposits are required, use appropriate build-up materials before hardfacing.

d. The combination of alloy content, carbon content, massive size and part rigidity creates a necessity to (**preheat, pressure wash**) in many build-up and hardfacing operations.

e. A large job may require (**reheating, preheating**) to keep interpass temperature at a proper level, and when a job is interrupted for a length of time, like a lunch break, preheat the base metal again.

f. A small amount of distortion can destroy the usability of some parts so rigid bracing, prebending, or other (**distortion, holding**) control techniques may be required.

Objective 7

Select true statements about cautions for hardfacing ventilation safety by placing an "X" in the blanks next to the true statements.

_____ a. Fumes from the normal use of certain hardfacing and welding products contain significant quantities of components such as chromium and manganese which can lower the maximum exposure guidelines for general welding fumes.

_____ b. Hardfacing requires a good exhaust system and in some cases may require special ventilation depending on the electrode used.

_____ c. Hardfacing outdoors requires careful attention to wind-blown fumes and keeping your head away from dangerous fumes.

_____ d. In other outdoor hardfacing where an operator may be working in a confined space such as a tank or enclosed area, always wear a face shield.

Objective 8

Complete statements about heat treating cautions by circling the correct answers.

a. Manganese steel becomes (**slightly soft, brittle**) if overheated; while 100°F to 200°F may be required, do not allow interpass temperature to exceed 500°F.

b. Some alloy steel components require a specific heat treatment to perform properly in service; this must be considered in preheating and hardfacing and may require (**contacting the part manufacturer, a metallurgical analysis**).

Objective 9

Select true statements about guidelines for heavy construction hardfacing by placing an "X" in the blanks next to the true statements.

_____ a. Whether removing earth cover prior to coat or mineral excavation or building highways or other construction projects, power shovel buckets and bucket teeth are subjected to varying degrees of abrasion and impact which will indicate the type of hardfacing materials to be used.

_____ b. General rules for hardfacing bucket teeth call for hardfacing the top of the leading edge of the bucket lip solid from the tip back approximately 4"; the balance of the beads should be applied according to type of service such as dirt, clay or sand, rock or slag, or for both rock and sand or dirt.

Objective 10

Complete statements about hardness ratings for hardfacing electrode by circling the correct answers.

a. Generally speaking, hardfacing or surfacing electrodes are rated on a rockwell C hardness scale of (**15 to 65, 10 to 70**) with (**15**, **10**) being least hard and (**65**, **70**) being hardest.

b. The AWS classificaiton for surfacing electrodes is a general classification of A5.33; 2000; other AWS classifications like E6010 relate an electrode to properties such as tensil strength but surfacing electrodes have no tensile strength and should not be used for (**joining metals, overhead welding**).

c. Hardness factors are critical to (**filler metal selection, preheating requirements**) and must be suitable for the metal in the part being hardfaced.

d. Hardfacing should be suitable for machining if machining is required to obtain contour or other operating characteristics, and this requries care because some hardfacing electrodes leave deposits so hard they (**cannot be machined**, **can be machined only with difficulty**).

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1

a. 4
b. 2
c. 1
d. 3

Objective 2

a. low-cost
b. worn, new

Objective 3

a, c

Objective 4

a. versatility
b. downhand
c. lower
d. human error

Objective 5

a. 5
b. 7
c. 2
d. 3
e. 4
f. 1
g. 6

Objective 6

a. cleaning
b. machine
c. excessive
d. preheat
e. reheating
f. distortion

Objective 7

a, b, c

Objective 8

a. brittle
b. contacting the part manufacturer

Objective 9

a

Objective 10

a. 15 to 65, 15, 65
b. joining metals
c. cannot be machined

Unit Contents

Teacher Components

	Teacher Page
Suggested Activities	4–3
Written Test	4–7
Answers to Written Test	4–11

Student Components

	Student Page
Learning Activities Sheet	4–3
Objective Sheet	4–5
Information Sheet	4–7
*Job Sheets	
1—Gouge a Piece of Mild Steel With the Carbon Arc Arc Cutting—Air Process	163
2—Backgouge a Piece of Mild Steel Beveled Plate With the Carbon Arc Cutting—Air Process	167

*The Job Sheets are located in the Student Workbook.

Suggested Activities

Instructional Plan

Preparation

- Read the unit carefully and plan for instruction.
- Review "Teaching Suggestions." Plan for classroom activities.
- Plan your presentation to take advantage of student learning styles and to accommodate special-needs students.
- Prepare classroom. Put up posters and charts and display articles and other references related to this unit.
- Obtain films, videotapes, and other resources to supplement instruction of this unit. See "Resources Used in Developing This Unit" and "Suggested Supplemental Resources" for more information.
- For self-paced instruction, review Learning Activities Sheet. Modify as appropriate to include additional activities and/or resources available in your classroom. Make one copy for each student.

Delivery and Application

Unit Introduction (self-paced instruction)

- Provide student with Learning Activities Sheet and unit of instruction.
- Review unit contents with student.
- Have the student complete the steps in the learning activities sheet.

Unit Introduction (group instruction)

- Provide students with unit of instruction.
- Discuss unit and specific objectives.
- Discuss the information sheet. Implement teaching plan to localize, supplement, and personalize the unit. Reinforce basic academic and workplace skills when applicable.

Teaching Suggestions

- Discuss the versatility of carbon arc cutting in general and note how the portability factor makes it a very useful cutting process.
- Discuss compressed air supplies used in carbon arc cutting—air and stress the importance of testing the air supply for moisture before starting a gouging process.

Suggested Activities

- Demonstrate the process of preparing for and completing Job Sheet 1 and stress safety factors, especially the need to wear a welding helmet and ear plugs because carbon arc cutting—air is truly a noisy process.

- Prepare students for Job Sheet 2 by checking for appropriate workpieces that should have been saved from the V-groove job sheets in Unit 2.

- Review Objective 11 and demonstrate how backgouging prepares the other side of a weld for a complete penetration weld.

Evaluation

- Make copies of the written test. Add or modify test items as needed. The written test serves as both a pretest and posttest to assist in measuring each student's competency gains.

- Give and evaluate pretest. Modify lesson plan to include additional instruction for those areas where students were deficient.

- Evaluate the job sheets. When the student is ready to perform a specific task, obtain a copy of the job sheet which may be found in the student edition. Then observe the student performing the procedure.

  Process evaluation—Place a mark in the box to the left of each designated checkpoint if the student has satisfactorily completed the process step(s) for each checkpoint area. If the student is unable to complete the procedure correctly, have the student review the materials and try again.

  Product evaluation—Once the student has satisfactorily completed the procedure, rate the student product (outcome) using the criteria that are provided as part of the job sheet. If the student's product is unacceptable, have the student review the materials and submit another product for evaluation.

Two sample performance evaluation keys have been provided below. Many other keys are available. Select one rating (grading scale) that best fits your program needs.

Sample A

4—**Skilled**—Can perform job with no additional training.
3—**Moderately skilled**—Has performed job during training program; limited additional training may be required.
2—**Limited skill**—Has performed job during training program; additional training is required to develop skill.
1—**Unskilled**—Is familiar with process, but is unable to perform job.
0—**No exposure**—No information or practice provided during training program.

Sample B

Yes—Can perform job with no additional training.
No—Is unable to perform job satisfactorily.

- Give and evaluate the posttest.
- Meet individually with students to evaluate their progress through this unit of instruction and indicate to them possible areas of improvement.
- Reteach and retest as required.

Resources Used in Developing This Unit

Print Media

- O'Brien, R.L., ed. *Welding Processes, Welding Handbook*, 8th ed. Vol. 2. Miami, FL; American Welding Society, 1991.
- *The Procedure Handbook on Arc Welding*. 13th ed. Cleveland, OH: the Lincoln Electric Company, 1993..
- *Recommended Practices for Air Carbon Arc Gouging and Cutting*. This ANSI-approved 19-page guide was published in 1991 by the American Welding Society and is available at a nominal fee to the public (AWS members get a discount). To order, call AWS at (800) 334-9353 or contact AWS on the internet at http://www.aws.org.

Written Test

Name _____

Date _____ Score _____

Objective 1

Match the terms with their definitions.

1. Back weld
2. Backgouging
3. Arc cutting
4. Gouging

_____ a. A group of cutting processes that melt the base metal with the break of an arc between the electrode and the base metal; air carbon arc cutting is a variation of the process that produces a gouge in a base metal instead of totally cutting it

_____ b. The removal of weld metal and base metal from the other side of a partially welded joint to facilitate complete fusion and complete joint penetration upon subsequent welding from that side

_____ c. A weld made at the back of a single groove weld

_____ d. The forming of a bevel or groove by material removal

Objective 2

Select true statements about the principles of air carbon arc cutting by placing an "X" in the blanks next to the true statements.

_____ a. CAC—A is a cutting process that cuts or gouges metal by using an electric arc between a carbon electrode and a base metal.

_____ b. As the arc melts the base metal, a controlled stream of compressed air is directed at the arc to remove molten metal to make a complete cut or produce a groove.

_____ c. CAC—A is popular because the equipment required is only a standard welding machine.

Objective 3

Select true statements about CAC—A power sources by placing an "X" in the blanks next to the true statements.

_____ a. Standard power sources for arc welding can be used for CAC—A, but an opening circuit voltage of at least 50 volts is required.

_____ b. Air pressure required to make a cut depends on the diameter of the carbon electrode, and air pressures usually range from a minimum of 40 psi to 80 psi and above.

Written Test

Objective 4

Match types of CAC—A electrodes with their characteristics by placing the number of the electrode type beside the correct definition

1. Flux-coated steel 2. Graphite 3. Copper-coated

_____ a. Made of graphite (carbon) for DC operation in sizes of 5/32″ to 1″

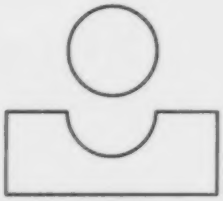
_____ b. Used for cutting or gouging high-purity copper or cast iron and available with a 1/4″ diameter and 18″ long

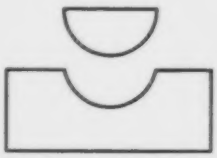
_____ c. Electrode has no copper coating, which tends to make the electrode "pencil" or cause a gradual decrease in the size of a groove.

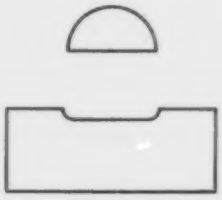
Objective 5

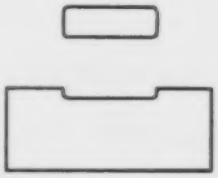
Match CAC—A electrode shapes with their uses by placing the numbered electrode type beside the correct illustration.

1. Used to gouge a flat groove
2. Used to gouge a U groove
3. Can be turned to gouge a flat groove
4. Can be used to gouge a U groove

_____ a. 

_____ b. 

_____ c. 

_____ d. 

111

Objective 6

Match CAC—A electrode angles with their uses by placing the numbered angle beside the correct definition.

1. More than 45° between electrode and work
2. 35° to 45° between electrode and work
3. Less than 35° between electrode and work

_____ a. The preferred angle for gouging

_____ b. A nonpreferred angle that is higher and causes the groove to cut deeper into the base metal and impair metal removal

_____ c. A nonpreferred angle that is lower and causes the groove not to cut as deeply into the metal base

Objective 7

Complete statements about amperage selection for gouging by circling the information that best completes each statement.

a. Amperage should be selected according to power source and (**job at hand, electrode size**).

b. When amperage is lower than recommended, the groove will retain a U shape, but it will be (**shallow, rough**).

c. When amperage is higher than recommended, approximately 15 percent higher, the groove will change from a U to a (**W, V**) shape.

d. When amperage is set as recommended, the groove will have a uniform U shape with good (**depth, surface**).

Objective 8

Complete statements about air pressure and how it affects gouging by circling the information that best completes each statement.

a. Low air pressure tends to produce (**an irregular surface and edge, a shallow groove**).

b. Correct air pressure allows for (**deep, slag-free**) cuts.

Objective 9

Complete statements about travel speed and how it affects gouging by circling the information that best completes each statement.

a. Slow travel speed generates more heat input into the base metal and produces a (**wider, deeper**) groove.

b. High travel speed (**increases, decreases**) metal removal, and as travel speed (**increases, decreases**), metal removal (**increases, decreases**) accordingly

c. Correct travel speed produces a groove (**width, depth**) that is approximately half the diameter of the electrode.

Objective 10

Match techniques for gouging with their procedures by placing the numbered technique beside the correct definition.

1. Horizontal gouging
2. Overhead gouging
3. Vertical gouging

_____ a. Should be done in the down direction to allow for safe removal of molten metal

_____ b. May be done left or right, but airstream must remain behind the electrode with respect to the direction of travel

_____ c. Requires that the electrode be perpendicular to the base metal and angled so that molten metal will not drop on the operator

Objective 11

Select true statements about when to use backgouging by placing an "X" in the blanks next to the true statements.

_____ a. To consistently complete fusion when welding a plate, backgouging is required on virtually all joints except T-joints in overhead welds.

_____ b. Although grinding and chipping can accomplish gouging, backgouging with an electrode is generally the quickest and most economical, and when properly accomplished, can leave an ideal contour for finishing a weld.

_____ c. The major rule is backgouging is that the gouge should be deep enough to expose the other side of the weld.

_____ d. Backgouging may need to be followed by back-chipping to expose sound weld metal and provide complete accessibility for the correct electrode angle.

_____ e. Cutting goggles do not provide enough protection for backgouging, so always wear a welding helmet, and because backgouging can be a very noisy process, ear plugs are highly recommended.

***Permission to duplicate this test is granted.**

Answers to Written Test

Objective 1	a. 3 b. 2 c. 1 c. 4
Objective 2	a, b
Objective 3	a, b
Objective 4	a. 3 b. 1 c. 2
Objective 5	a. 2 or 4 b. 2 or 4 c. 3 d. 1
Objective 6	a. 2 b. 1 c. 3
Objective 7	a. Electrode size b. Shallow c. V d. Depth
Objective 8	a. An irregular surface and edge d. Slag-free
Objective 9	a. Deeper b. Decreases, increases, decreases c. Depth
Objective 10	a. 3 b. 1 c. 2
Objective 11	a, c, d, e

Shielded Metal Arc Welding and Carbon Arc Cutting - Air

THIRD EDITION

MAVCC

Student Edition

BEST COPY AVAILABLE

Shielded Metal Arc Welding and Carbon Arc Cutting—Air

Third Edition

Student Edition

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Table of Contents

Units of Instruction

Unit 1: SMAW Safety

Unit 2: SMAW Equipment, Applications, and Techniques

Unit 3: Hardfacing

Unit 4: Carbon Arc Cutting—Air

118

Unit Contents

Student Components

	Student Page
Learning Activities Sheet	1–3
Objective Sheet	1–5
Information Sheet	1–7
*Assignment Sheet	
1—Solve Problems Concerning SMAW Safety	1

*The Assignment Sheet is located in the Student Workbook.

119

Prerequisites:
None

Learning Activities Sheet

Student Name _____

Place a checkmark in the appropriate box as you complete each of the steps below.

❑ 1.	**Take**	Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.
❑ 2.	**Read**	Objective Sheet.
❑ 3.	**Study**	Information Sheet, Objectives 1 through 7.
❑ 4.	**View**	Videotape entitled *Arc Welding Safety* and/or *Health and Safety Factors in Welding Operation.*
❑ 5.	**Study**	Information Sheet, Objectives 8 through 11.
❑ 6.	**Do**	Assignment Sheet 1, "Solve Problems Concerning SMAW Safety."
❑ 7.	**Stop**	Have instructor evaluate the completed assignment sheet and if the evaluation is satisfactory, continue to step 8. If the evaluation is not satisfactory, repeat steps 3, 5, and 6.
❑ 8.	**Check**	With instructor for any additional assignments to be completed.
❑ 9.	**Do**	Additional assignments listed below.
❑ 10.	**Take**	Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.
❑ 11.	**Stop**	Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

_____

_____

_____

Optional

***Permission to duplicate this form is granted.**

Objective Sheet

Unit Objective

After completing this unit, the student should be able to discuss safety requirements for Shielded Metal Arc Welding and Carbon Arc Cutting—Air and solve problems concerning SMAW safety. The student should demonstrate these competencies by completing the assignment sheet and by scoring a minimum of 100 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to SMAW safety with their definitions.
2. Select true statements concerning electrical safety for arc welding.
3. Complete statements concerning rules for handling welding cables.
4. Complete statements concerning rules for handling hollow castings and containers.
5. Select solutions for hazards from arc rays.
6. Solve problems concerning guidelines for duty cycle safety.
7. Complete statements concerning types of welding hoods.
8. Complete a list of steps in selecting a safe lens shade for shielded metal arc welding.
9. Solve problems concerning protective clothing required for arc welding.
10. Solve problems concerning environmental problems and their safety requirements.

*11. Solve problems concerning SMAW safety. (Assignment Sheet 1)

*The Assignment Sheet is located in the Student Workbook.

Information Sheet

Objective 1

Terms and definitions

a. **Contaminants**—Elements in the atmosphere and/or impurities formed from chemical reactions between a base metal, filler metal, electrode, or shielding gas

b. **Oxygen displacement**—The tendency of any arc or flame to reduce oxygen in the breathing zone around a welding activity

c. **Toxic hazards**—Poisonous gases, fumes, and vapors produced by chemical reactions in certain welding processes

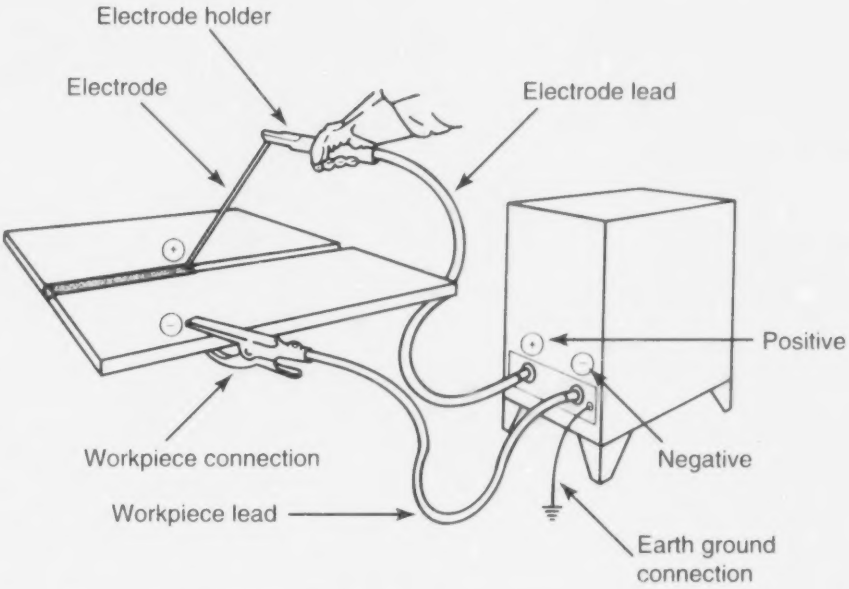
> **Caution:** Toxic hazards and contaminants are usually present in fumes and vapors.

Objective 2

Electrical safety for arc welding

a. All electrical equipment should have an earth ground for safety reasons, and this ground should not be confused with the work lead to workpiece ground that completes the welding circuit.

Figure 1



Courtesy of The American Welding Society.

b. Keep electrical connections tight, clean, and dry because poor connections can heat up, cause bad welds, produce dangerous arcs and sparking, and even melt.

c. Keep work area, equipment, and clothing dry because even a slight amount of moisture can conduct enough electricity to cause a severe shock.

d. Never dip an electrode holder in water to cool it.

e. When working with welding machines set up for multiple operation, be very careful not to touch hot parts of the electrode holders because open-circuit voltages from two machines are increased and can cause a severe shock.

f. Remove electrode from electrode holder when work is finished.

g. Disconnect and lock out all electric power sources before doing any work on electrical equipment.

h. When working in high places, carefully examine work area for electrical hazards because a shock in such conditions could cause a fall and severe injury.

i. Keep welding cables free of conduits, motors, and any other equipment that could cause a short circuit.

j. Keep ground as far away from the arc as possible.

Objective 3

Rules for handling welding cables

a. Never drag a welding cable through oil, and never pull on a cable to force it over an obstruction.

b. Use only clean, dry rags to clean welding cables, and never use gasoline or an oily rag to clean a cable.

c. When not in use, keep welding cables free of kinks and properly stored on a flat surface off the floor.

d. Never drape a welding cable over any type of gas cylinder.

Objective 4

Rules for handling hollow castings or containers

a. Hollow castings or containers should be vented before any heating, cutting, or welding activity.

b. Tanks, drums, and containers should not be heated, cut, or welded.

c. The rule for beginning welders is to never attempt heating, cutting, or welding on hollow castings or containers.

Objective 5

Hazards from arc rays

a. A welding arc produces ultraviolet and infrared radiation that can severely burn eyes that are unprotected with a proper shade of protective lens.

Note: A welding hood or helmet protects the head from flying sparks, but the shaded lens and safety glasses are also required for eye protection.

b. Radiation from a welding arc is strong enough to burn or sometimes blister bare skin if the exposure is intense or for an extended period, so arms, legs, and torso should be covered with durable flame-resistant clothing.

c. Workstations and work areas should be shielded to prevent an arc flash from injuring nearby workers or visitors.

Objective 6

Guidelines for duty cycle safety

a. Duty cycle is a performance reference used to avoid overheating and perhaps ruining a welding machine.

b. Duty cycle is based on a ten minute period and the length of time during that period that a machine can be safely operated.

c. A machine with a 20 percent duty cycle could safely operate 2 minutes out of each 10 minute period.

d. Since duty cycle is rated at the maximum output of a welding machine at a given amperage setting, the lower the percentage, the more attention is required to time spent actually welding.

Objective 7

Types of welding hoods and their characteristics

a. **Stationary filter lens**—This type hood has a fixed lens housing with the shaded lens held in by a spring retainer from where a lens can be slipped out and replaced as welding requires.

Note: Always check the clear face lens to make sure it's clean and free of scratches.

Figure 2

b. **Flip-front filter lens**—This type hood has a lens housing with a front side that can be flipped up so that it leaves a clear-glass or plastic lens that permits the hood to be worn while chipping.

Note: Always check the clear face lens to make sure it's clean and free of scratches.

Figure 3

c. **Auto darkening lens**—This type of lens is used with a helmet specifically designed for auto darkening lenses.

- Contains sensors that automatically change the shade lens from clear to dark in a fraction of a second when you start to weld
- Gradually changes from dark to clear when you stop welding
- Can be manually adjusted to a variety of shades

Figure 4

Objective 8

Guidelines for selecting a safe lens shade for SMAW

a. Determine electrode size and amperage range for the electrode because electrode size and amperage used dictate the lens protection required.

b. Select lens shade according to the lens manufacturer's selection chart, but never select less than a #8 lens shade for SMAW.

c. When you remove your hood after arc welding and you see white spots or white blotches as after images, it means that you are getting too much light through the lens and you should switch to a shade at least one number darker, or check the seal on your lens.

Electrode Size	Amperage	Shade #
	30 to 75	8
1/16-5/32	75 to 200	10
3/16-1/4	200 to 400	12
5/16-3/8	400+	14

d. A rule of thumb is that the larger the diameter of the electrode, the higher the number required for a lens shade.

Objective 9

Protective clothing required for arc welding

Caution: Always avoid clothing with tears, snags, rips, or worn spots. They are easily ignited by sparks.

a. **Shirts**

- Should be heavy, long-sleeve shirts with pocket flaps
- Keep collar and sleeves buttoned to keep out sparks, and remove pockets from front of shirt or tape them shut if they don't have pocket flaps

Figure 5

b. **Pants**

- Should not have cuffs
- Should be long enough to come down over shoe/boot tops

Caution: Clothes made of polyester and other synthetics catch fire easily so it's better to wear wool or heavily-starched cottons.

c. **Gloves**—Heavy leather gloves with gauntlets are required for all welding and cutting activities

d. **Welding caps**

- Should be worn to protect hair from sparks and spatter
- Should have a flexible bill that can be slipped around to cover either ear to keep sparks or metal spatter out of the ear opening

> **Caution:** Some hair sprays are highly flammable and can be ignited by sparks, and any kind of plastic hair cap or covering is dangerous in the welding area.

Figure 6

e. **Boots**

- Should be made of heavy leather with uppers that reach above the ankle to help prevent burns from sparks and spatter
- Should be steel toed

  Note: Steel-toed boots are required in many states.

- If low-topped shoes are worn, the ankles should be protected by fire-resistant leggings.

  Note: Never wear sneakers, tennis shoes, sandals, or loafer-type shoes when welding.

f. **Jackets and aprons**—Leather jackets and aprons should be worn for additional protection, especially when welding out of position or in confined areas where flying sparks present an increased hazard.

Figure 7

Leather Jacket Fire-proof jacket

g. **Safety glasses**

- Should have nonmetal frames
- Should have impact-resistant lenses with side shields to protect from flying objects (Complies with ANSI 287.1-1989.)
- Should be worn at all times in the shop area

Figure 8

129

h. **Face shield**—Wear a clear-plastic type of face shield to provide good visibility when grinding or chipping and to provide protection from slag or metal.

Figure 9

Note: Do not substitute a face shield for safety glasses. Safety glasses should be worn at all times in the welding workplace.

i. **Hard hats**—Wear a hard hat in situations where the danger of falling materials or tools may be present.

Note: In certain job situations, wearing a hard hat may be a requirement of the contractor.

Objective 10

Environmental safety requirements

a. **Ventilation**—Many welding activities produce toxic fumes and vapors that are hazardous to breathe, and every workstation should be equipped with a ventilation or exhaust system capable of safely removing dangerous and irritating smoke and contaminants.

> **Caution**: Over ventilation can interfere with the welding process, so make proper considerations and always position your head out of the path of rising fumes.

b. **Respirators**—Working in confined spaces where toxic fumes are a hazard requires wearing a respirator that can compensate for oxygen displacement, but irritation from other welding fumes and gases can be avoided by wearing a respirator with a filter-type mask.

Figure 10

Courtesy Fibre-Metal Products

c. **Noise**—This is a workplace hazard frequently overlooked, but earplugs or muffler-type ear protectors should be worn when the work area subjects a welder to high noise levels, especially high noise levels that are continuous.

d. **Lighting**—Lighting in a work area or at a workstation should be bright enough to provide good visibility free of glare because poorly lit work areas contribute to eye fatigue, irritation, and poor work.

Unit Contents

Student Components

	Student Page
Learning Activities Sheet	2–3
Objective Sheet	2–5
Information Sheet	2–9
Student Supplement	
1—Electrode Selection Carbon and Low Alloy Steel	2–31
*Job Sheets	
1—Start and Restart an Arc, Crater, and Backfill at the Edge While Running a Bead on Mild Steel Plate	3
2—Build a Pad on Mild Steel Plate in the Flat Position with an E6010 Electrode	9
3—Build a Pad on Mild Steel Plate in the Flat Position with an E7018 Electrode	15
4—Weld to Specifications a Fillet Weld Lap Joint in the Flat Position with an E6010 Electrode	21
5—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Flat Position with an E6010 Electrode	25
6—Weld to Specifications a Fillet Weld Lap Joint in the Flat Position with an E7018 Electrode	29
7—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Flat Position with an E7018 Electrode	33
8—Weld to Specifications a Fillet Weld Lap Joint in the Flat Position with an E7024 Electrode	37
9—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Flat Position with an E7024 Electrode	41
10—Weld to Specifications a Fillet Weld Lap Joint in the Horizontal Position with an E6010 Electrode	45
11—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Horizontal Position with an E6010 Electrode	49
12—Weld to Specifications a Fillet Weld Lap Joint in the Horizontal Position with an E7018 Electrode	53
13—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Horizontal Position with an E7018 Electrode	57
14—Weld to Specifications a Fillet Weld Lap Joint in the Horizontal Position with an E7024 Electrode	61
15—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Horizontal Position with an E7024 Electrode	65
16—Weld to Specifications a Fillet Weld Lap Joint in the Vertical Position with an E6010 Electrode	69
17—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Vertical Position with an E6010 Electrode	73

Unit Contents

18—Weld to Specifications a Fillet Weld Lap Joint in the Vertical Position with an E7018 Electrode 77
19—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Vertical Position with an E7018 Electrode 81
20—Weld to Specifications a Fillet Weld Lap Joint in the Overhead Position with an E6010 Electrode 85
21—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Overhead Position with an E6010 Electrode 89
22—Weld to Specifications a Fillet Weld Lap Joint in the Overhead Position with an E7018 Electrode 93
23—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Overhead Position with an E7018 Electrode 97
24—Weld to Specifications a V-Groove Butt Joint in the Flat Position with an E6010 Electrode 101
25—Bend Test a Welded V-Groove Joint 107
26—Weld to Specifications a V-Groove Butt Joint in the Horizontal Position with an E6010 Electrode 111
27—Weld to Specifications a V-Groove Butt Joint . . . . . in the Vertical Position with an E6010 Electrode 117
28—Weld to Specifications a V-Groove Butt Joint in the Overhead Position with an E6010 Electrode 123
29—Weld to Specifications a V-Groove Butt Joint in the Flat Position with an E6010 Electrode Root and an E7018 Electrode Fill and Cap 129
30—Weld to Specifications a V-Groove Butt Joint in the Horizontal Position with an E6010 Electrode Root and an E7018 Electrode Fill and Cap 135
31—Weld to Specifications a V-Groove Butt Joint in the Vertical Position with an E6010 Electrode Root and an E7018 Electrode Fill and Cap 141
32—Weld to Specifications a V-Groove Butt Joint in the Overhead Position with an E6010 Electrode Root and an E7018 Electrode Fill and Cap 147

*The Job Sheets are located in the Student Workbook.

Prerequisites:

Learning Activities Sheet

Student Name _____

Place a checkmark in the appropriate box as you complete each of the steps below.

❑ 1.	**Take**	Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.
❑ 2.	**Read**	Objective Sheet.
❑ 3.	**Study**	Information Sheet, Objectives 1 through 10.
❑ 4.	**View**	Videotape entitled, *Welding So Hot It's Cool.*
❑ 5.	**Study**	Information Sheet, Objectives .
❑ 6.	**Observe**	Demonstration of procedures to be used in completing Job Sheet 1.
❑ 7.	**Do**	Job Sheet 1, "Title of job sheet."
❑ 8.	**Stop**	Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 9. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 1 and repeat steps 5, 6, and 7.
❑ 9.	**Study**	Information Sheet, Objectives 14 through 18.
❑ 40.	**Check**	With instructor for any additional assignments to be completed.
❑ 41.	**Do**	Additional assignments listed below.

_____

_____

_____

❑ 42.	**Take**	Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

Optional

❑ 43. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

*Permission to duplicate this form is granted.

Objective Sheet

Unit Objective

After completing this unit, the student should be able to weld fillet and groove welds in all positions, test fillet and groove welds, and use air carbon arc cutting equipment to gouge mild steel plate. The student should demonstrate these competencies by completing the job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to SMAW equipment, applications, and techniques with their definitions.
2. Select true statements concerning advantages of SMAW.
3. Complete statements concerning the principles of SMAW.
4. Solve problems concerning the relationship of arc, base metal, electrode, and flux.
5. Differentiate between elements of flux-covered electrode functions.
6. Select true statements concerning benefits of learning SMAW.
7. Match welding machines with their electrical characteristics.
8. Match welding machine performance characteristics with their applications.
9. Complete statements concerning basic SMAW accessories and their purposes.
10. Complete statements concerning AWS electrode classifications for mild steel and low alloy electrodes.
11. Differentiate between stainless steel and other alloy electrodes.
12. Complete statements concerning basic elements of arc welding and their importance.
13. Differentiate between electrode angles.
14. Differentiate between SMAW starting techniques.
15. Complete statements concerning techniques for controlling arc gap.
16. Complete statements concerning techniques for using electrode angles.
17. Match bead running techniques with their procedures.

Objective Sheet

18. Select true statements concerning the techniques for stopping and restarting an arc.

19. Complete statements concerning techniques for filling a crater at the end of a weld.

20. Select guidelines for using feathered edges for tie-ins.

21. Differentiate between basic steps in joint preparation.

22. Match good and bad welds with their characteristics.

23. Select causes of and remedies for arc blow.

24. Select causes of and remedies for pinholes and porosity.

25. Select causes of and remedies for undercutting.

26. Select causes of and remedies for weld spatter.

27. Select causes of and remedies for incomplete penetration.

28. Select causes of and remedies for slag inclusion.

29. Select causes of and remedies for excessive weld reinforcement.

30. Select true statements concerning the principles of air carbon arc cutting.

31. Select true statements concerning CAC-A power sources.

32. Match types of CAC-A electrodes with their characteristics.

33. Match CAC-A electrode shapes with their uses.

34. Match CAC-A electrode angles with their uses.

35. Complete statements concerning amperage selection for gouging.

36. Complete statements concerning air pressure and how it affects gouging.

37. Complete statements concerning travel speed and how it affects gouging.

38. Match techniques for gouging with their procedures.

39. Complete statements concerning hardfacing.

40. Select true statements concerning elements affecting hardfacing.

41. Complete statements concerning electrode drying ovens.

*42. Start and restart an arc, crater, and backfill at the edge while running a bead on mild steel plate. (Job Sheet 1)

*43. Build a pad on mild steel plate in the flat position with an E6010 electrode. (Job Sheet 2)

*44. Build a pad on mild steel plate in the flat position with an E7018 electrode. (Job Sheet 3)

*45. Weld to specifications a fillet weld lap joint in the flat position with an E6010 electrode. (Job Sheet 4)

*46. Weld to specifications a multipass fillet weld on a T-joint in the flat position with an E6010 electrode. (Job Sheet 5)

*47. Weld to specifications a fillet weld lap joint in the flat position with an E7018 electrode. (Job Sheet 6)

*48. Weld to specifications a multipass fillet weld on a T-joint in the flat position with an E7018 electrode. (Job Sheet 7)

*49. Weld to specifications a fillet weld lap joint in the flat position with an E7024 electrode. (Job Sheet 8)

*50. Weld to specifications a multipass fillet weld on a T-joint in the flat position with an E7024 electrode. (Job Sheet 9)

*51. Weld to specifications a fillet weld lap joint in the horizontal position with an E6010 electrode. (Job Sheet 10)

*52. Weld to specifications a multipass fillet weld on a T-joint in the horizontal position with an E6010 electrode. (Job Sheet 11)

*53. Weld to specifications a fillet weld lap joint in the horizontal position with an E7018 electrode. (Job Sheet 12)

*54. Weld to specifications a multipass fillet weld on a T-joint in the horizontal position with an E7018 electrode. (Job Sheet 13)

*55. Weld to specifications a fillet weld lap joint in the horizontal position with an E7024 electrode. (Job Sheet 14)

*56. Weld to specifications a multipass fillet weld on a T-joint in the horizontal position with an E7024 electrode. (Job Sheet 15)

*57. Weld to specifications a fillet weld lap joint in the vertical position with an E6010 electrode. (Job Sheet 16)

*58. Weld to specifications a multipass fillet weld on T-joint in the vertical position with an E6010 electrode. (Job Sheet 17)

*59. Weld to specifications a fillet weld lap joint in the vertical position with an E7018 electrode. (Job Sheet 18)

*60. Weld to specifications a multipass fillet weld on a T-joint in the vertical position with an E7018 electrode. (Job Sheet 19)

*61. Weld to specifications a fillet weld lap joint in the overhead position with an E6010 electrode. (Job Sheet 20)

*62. Weld to specifications a multipass fillet weld on a T-joint in the overhead position with an E6010 electrode. (Job Sheet 21)

*63. Weld to specifications a fillet weld lap joint in the overhead position with an E7018 electrode. (Job Sheet 22)

*64. Weld to specifications a multipass fillet weld on a T-joint in the overhead position with an E7018 electrode. (Job Sheet 23)

*65. Weld to specifications a V-groove butt joint in the flat position with an E6010 electrode. (Job Sheet 24)

*66. Bend test a welded V-groove joint. (Job Sheet 25)

*67. Weld to specifications a V-groove butt joint in the horizontal position with an E6010 electrode. (Job Sheet 26)

*68. Weld to specifications a V-groove butt joint in the vertical position with an E6010 electrode. (Job Sheet 27)

*69. Weld to specifications a V-groove butt joint in the overhead position with an E6010 electrode. (Job Sheet 28)

*70. Weld to specifications a V-groove butt joint in the flat position with an E6010 electrode root and an E7018 electrode fill and cap. (Job Sheet 29)

*71. Weld to specifications a V-groove butt joint in the horizontal position with an E6010 electrode root and an E7018 electrode fill and cap. (Job Sheet 30)

*72. Weld to specifications a V-groove butt joint in the vertical position with an E6010 electrode root and an E7018 electrode fill and cap. (Job Sheet 31)

*73. Weld to specifications a V-groove butt joint in the overhead position with an E6010 electrode root and an E7018 electrode fill and cap. (Job Sheet 32)

*The Job Sheets are located in the Student Workbook.

Information Sheet

Objective 1

Terms and definitions

a. **Air contaminants**—Hydrogen, oxygen, and nitrogen in air

b. **Axis of a weld**— line through the length of a weld, perpendicular to the corss-section at its center of gravity

c. **Cap pass**—The final bead or beads needed to complete a welded joint

d. **Deposition rate**—The weight of material deposited in a unit of time

e. **Filler pass**—The remainder of the beads required to complete the joint from the root bead out to the cap pass

f. **Root bead**—A weld bead that extends into or includes parts or all of the joint root

g. **Shielding**—Any procedure or device for protecting an in-process weld from atmospheric contamination

h. **Slag**—A nonmetallic product resulting from the mutual dissolution of flux and nonmetallic impurities in some welding and brazing processes

i. **Stringer bead**—A type of weld bead made without appreciable weaving motion

Objective 2

Advantages of SMAW

a. Equipment is relatively inexpensive.

b. Equipment is portable because the welding machines can be powered with gasoline or diesel powered engines

c. Applications are relatively simple and can be adapted to many job requirements.

d. SMAW is well suited for maintenance and repair work in small shops, on farms, and in garages.

Objective 3

Principles of SMAW

a. An electric arc is struck between a grounded base metal and a flux-covered electrode held in a holder and manipulated by hand.

b. The heat of the arc melts the base metal and the metal in the electrode so that the two fuse together to create the weld.

c. Flux contained on the electrode covering is also melted or vaporized to provide shielding that protects the weld from contaminants in the air, hence the name Shielded Metal Arc Welding and Carbon Arc Cutting—Air.

Objective 4

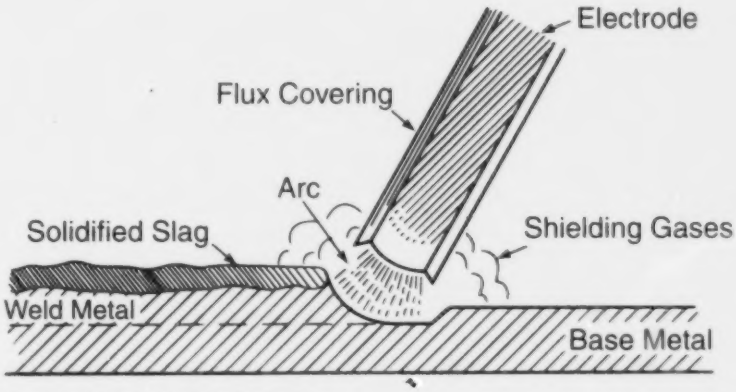
Relationships of arc, base metal, electrode, and flux

a. The arc stream is created by holding an electrode approximately 1/8" way from the base metal.

b. The arc stream creates a molten pool or crater that tends to flow away from the arc and cool and solidify as it moves.

c. Flux from the electrode covering forms a slag on the top of the weld to protect it from contaminants during cooling.

Figure 1



Courtesy of Lincoln Electric Company.

Objective 5

How flux-covered electrodes work

a. Flux-covered electrodes have a core of metal wire with a baked on chemical covering, and both parts of the electrode have specific functions.

b. The wire core melts in the arc stream and droplets of metal are transferred across the arc to make the molten puddle and provide the filler metal to fill the gap or groove between two base metals.

c. The flux covering also melts in the arc stream to stabilize the arc, to provide a shield around the arc to keep it free from atmospheric impurities, and to form a slag covering to protect the weld.

Objective 6

Benefits of learning SMAW

a. SMAW introduces a beginner to the basics of other arc welding processes.

b. SMAW acquaints the beginner with the welding machines and electrical accessories used in other arc welding processes.

c. SMAW introduces the beginner to the world of electrodes and their relationship to metal thicknesses, welding speeds, and amperage requirements.

d. SMAW acquaints the beginner with the basic concepts of shielding and how shielding improves and protects a weld.

e. SMAW helps the student develop the manual dexterity required to work with other arc welding processes.

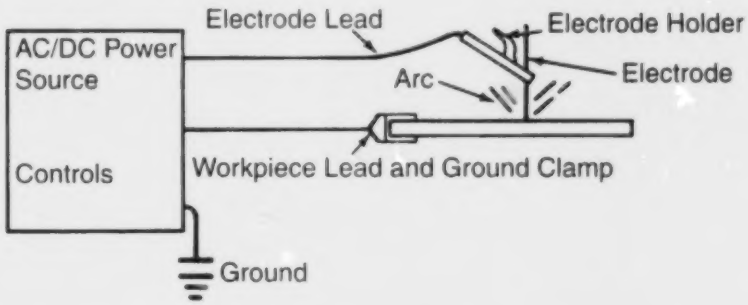
f. SMAW gives the beginner an added welding skill that will add versatility to job-getting resumés.

Objective 7

Welding machines and their electrical characteristics

a. Basic circuit—Current must travel in a complete loop from the power supply to the arc and back to the power supply, and the circuit must be grounded.

Figure 2



b. **Polarity**—This is the direction that current flows through a basic welding circuit, and is expressed as negative or positive in relation to DC current.

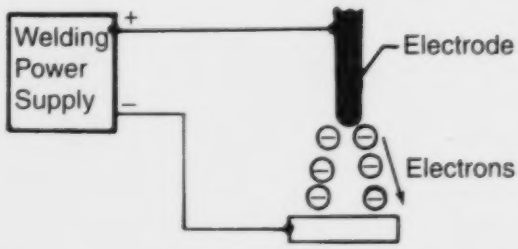
c. **AC (alternating current)**—This is current that alternates from one direction to another 60 times per second, and is expressed as 60 Hertz.

d. **DC (direct current)**—This is current that flows in only one direction.

e. **DCEN (direct current, electrode negative)**—This is produced by a negative electrode and a positive workpiece that causes the current to flow from the electrode to the workpiece.

Note: DCEN was formerly termed DCSP, direct current, straight polarity.

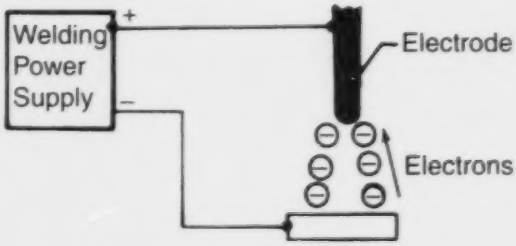
Figure 3



f. **DCEP (direct current, electrode positive)**—This is produced by a positive electrode and a negative workpiece that causes the current to flow from the workpiece to the electrode.

Note: DCEP was formerly named DCRP, direct current, reverse polarity.

Figure 4



Objective 8

Welding machine performance characteristics and their applications

a. **AC transformer**—These machines change high-voltage, low-amperage AC to low-voltage, high-amperage AC in machines that usually have a 220/240 volt input current.

b. **AC or DC transformer-rectifier**—These machines change high-voltage, low-amperage AC to low-voltage, high-amperage AC or DC, and these machines are ideal for adjustment to different materials and welding positions.

c. **DC generator (motor or engine)**—In these machines, current varies with the speed the armature turns, polarity changes may be made by flipping a switch or reversing weld connections, and some of these machines are powered with AC motors while others are powered with gas or diesel engines.

143

d. **Inverter power sources**—Utilizes solid-state components to change the incoming 60 Hz power to a higher frequency, nominally 18 to 100 kHz. Changing the frequency results in greatly reduced size and weight of the transformer. Can be used with all processes.

e. **Duty cycle**—The percentage of a 10-minute period that a welding machine can operate at a given output current.

Example: A welding machine rated at 60% duty cycle at 300 amps means that the machine can be on 6 out of 10 minutes; if the output current of the same machine were lowered, the duty cycle would rise accordingly.

Objective 9

Basic SMAW accessories and their purposes

a. Cables are insulated copper, extra-flexible leads that carry the current from the power source to the electrode, and they vary in size or diameter according to machine capacity and length requirements.

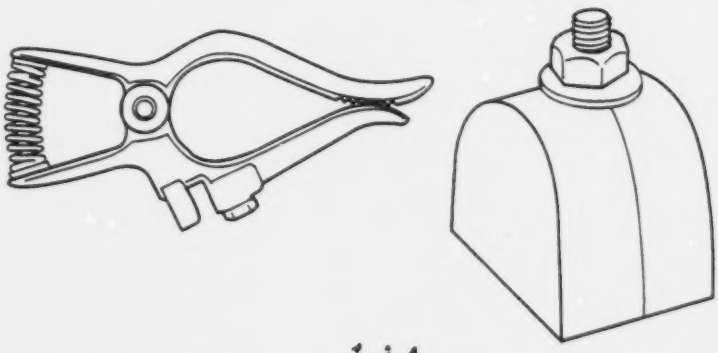
Table 2.1
Recommended Copper Welding Cable Sizes

Power Source		Awg Cable Size for Combined Length of Electrode and Ground Cables				
Size in Amperes	Duty Cycle, %	0 to 50 ft (0 to 15 m)	50 to 100 ft (15 to 30 m)	100 to 150 ft (30 to 46 m)	150 to 200 ft (46 to 61 m)	200 to 250 ft (61 to 76 m)
100	20	6	4	3	2	1
180	20-30	4	4	3	2	1
200	60	2	2	2	1	1/0
200	50	3	3	2	1	1/0
250	30	3	3	2	1	1/0
300	60	1/0	1/0	1/0	2/0	3/0
400	60	2/0	2/0	2/0	3/0	4/0
500	60	2/0	2/0	2/0	3/0	4/0
600	88	2/0	2/0	3/0	4/0	*

* Use two 3/0 cables in parallel.

b. Clamps are used to fasten the cables to workpiece or table where the workpiece is positioned so the welding circuit will be completed, and some operate with spring pressure while others are magnetic.

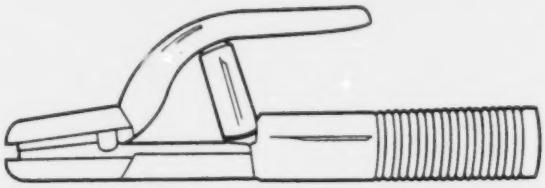
Figure 5



144

c. Electrode holders are hand-held clamping devices that hold the electrode during the welding process; they should be selected according to the machines maximum output rating, and they should be well insulated, lightweight to keep a welder from tiring, and sturdy enough to stand up under continued use.

Figure 6



Courtesy of Tweco.

Objective 10

AWS electrode classifications for mild steel and low alloy electrodes

a. The prefix "E" designates an "electric" arc welding electrode.

b. The first two digits of 4-digit numbers and the first three digits of 5-digit numbers indicate minimum tensile strength.

Examples:	E60XX	60,000-psi tensile strength
	E70XX	70,000-psi tensile strength
	E110XX	110,000-psi tensile strength

c. The next-to-last digit indicates position.

Examples:	EXX1X	All positions
	EXX2X	Flat positions and horizontal fillets

d. The last digit (0 through 8) together with the next-to-last digit indicate the type of covering and current to be used; mild steel electrodes are also classified as fast-freeze, fill-freeze, fast-fill, and low hydrogen.

e. The last letter and digit (EXXXX-A1) indicate the approximate alloy in the deposit.

Examples:	-A1	1/2° Mo
	-B1	1/2° Cr, 1/2° Mo
	-B2	1–1/4° Cr, 1/2° Mo
	-B3	2-1/4° Cr, 1% Mo
	-C1	2-1/2° Ni
	-C2	3-1/4° Ni
	-C3	1° Ni, 35% Mo, 15% Cr
	-D1 & D2	.25–.45% Mo, 1, 25–22.00% Mn
	-G	.50 min Ni, .30 min Cr., 20 min Mo, .10 min V (Only one of the listed elements is required.)

f. In addition the the AWS classification system, electrodes are also classified according to diameter expressed in fractions of an inch.

Objective 11

Stainless steel and other alloy electrodes and their classifications

a. Stainless steel electrodes are numbered to match specific types of stainless steel because the chemical composition of the electrode must match the alloys in the base metal.

b. With other alloy electrodes, chemical symbols precede the digits to indicate significant alloys in the electrode.

Examples: ECuSI means electrical electrode
Cu means copper
SI means silicon

ECuNI means electrical electrode
Cu means copper
NI means nickel

Objective 12

Basic elements of arc welding and their importance

a. Electrode selection must be related to both the type and thickness of a base metal.

b. Welding speed is the greatest factor in reducing welding costs, and one rule of thumb is to use the largest allowable electrode at the highest acceptable amperage.

c. In welding positions for vertical, overhead, and horizontal butt welds, the maximum size for an E6010 or E6011 is 3/16″ and for these same positions with a low-hydrogen electrode, the maximum size is 5/32″.

d. For joint preparation, a narrow V-groove in a butt joint will usually prevent the use of a large electrode on the first pass.

e. With fit-up, backup strips are permitted with most codes.

f. Machine capacity is important because amperage ratings on some welding machines may not be large enough to properly handle large electrodes.

g. Amp settings are always determined by electrode selection and welding position, and the rule of thumb is to turn your amps down when welding vertical up and to turn your amps up when welding vertical down.

h. The rule of thumb for voltage changes between the electrode and the base metal is that a long arc increases voltage and a short arc decreases voltage.

i. Polarity is determined by electrode selection, and correct polarity is extremely important in DC electric arc welding processes.

Objective 13

Essentials of a good weld

a. Correct electrode size

b. Correct current

c. Correct arc length or voltage

d. Correct travel speed

e. Correct electrode angle

Objective 14

Electrode angles and their meanings

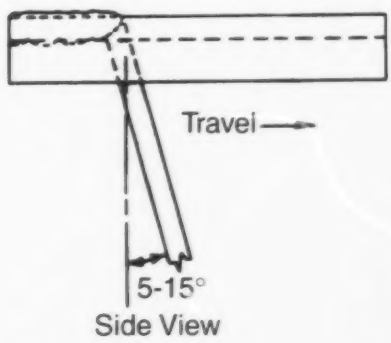
a. Electrode angles express two vital elements:

- The relationship of an electrode to the axis of the weld.
- The relationship of an electrode to the surface or surfaces of a workpiece.

b. Travel angle is the angle of an electrode in relation to the axis of a weld when the electrode is perpendicular to the axis.

Note: In the job sheets, travel angle is usually presented in a side view.

Figure 7

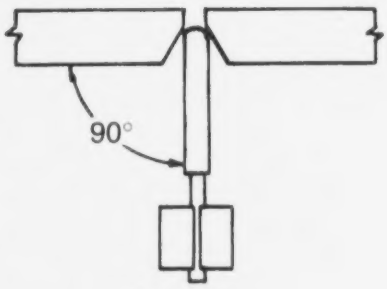


147

c. Work angle is the angle of an electrode in relation to the surface or surfaces of a workpiece when the electrode is perpendicular to the axis of the weld.

Note: In the job sheets, work angle is usually presented in a front view.

Figure 8



Front View

Objective 15

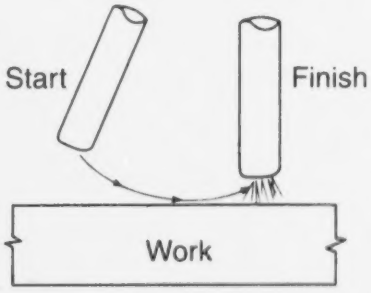
SMAW starting techniques

a. The technique most basic to all arc welding is to start and maintain an arc so that current is forced across the gap between the electrode tip and the base metal, and beginners should develop the skill of starting and maintaining an arc with a proper gap or arc length.

b. The "scratch method" for starting an arc is the simplest method for most beginners, and the scratch method works according to the following:

- Move the electrode across the base metal at an angle like you would use to strike a match.
- As the electrode scratches the base metal, an arc starts.
- When the arc starts, raise the electrode slightly to make a long arc, and then return to normal arc length.

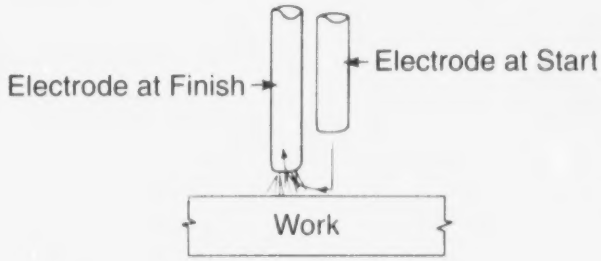
Figure 9



Courtesy of Lincoln Electric Company

c. The tap method for starting an arc is accomplished by moving the electrode downward in a vertical direction until it just taps the base metal, then raising the electrode up slightly to form a long arc, then returning to normal arc length again.

Figure 10



Courtesy of Lincoln Electric Company.

Objective 16

Techniques for controlling arc gap

a. Arc gap should usually be slightly less than the diameter of the electrode.

b. Too much gap can usually be identified by a hissing sound as opposed to a crackling sound.

c. Too much gap can be spotted visually because it has an open flame and causes excess spatter and poor penetration.

d. Too much gap will cause filler metal to melt off in large wobbly drops, and slag will be difficult to remove.

e. With too little gap, the arc will not start, or the electrode may freeze to the weld puddle and stick there.

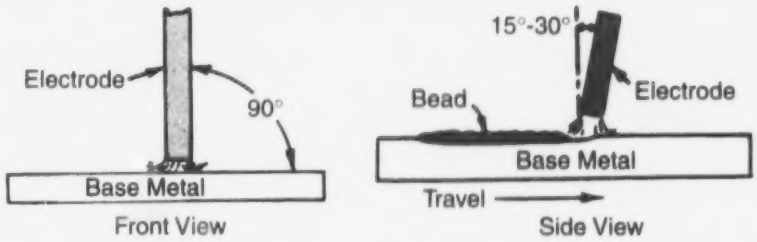
Objective 17

Techniques for using electrode angles

Note: Electrode angle will vary with electrode selection and welding position, but the following rules of thumb are good guidelines for beginners.

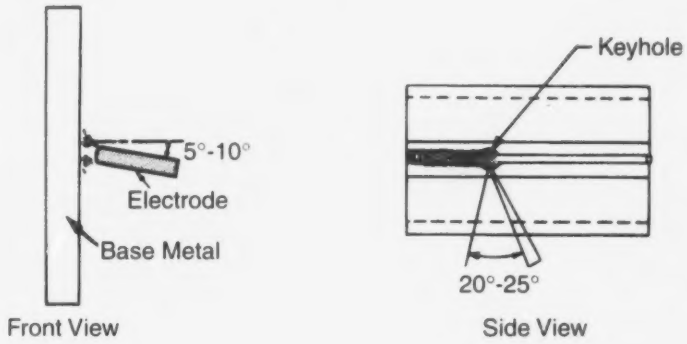
a. For right-hand welding of flat beads, place the electrode at 90° angle, then lean it 15° to 30° to the right so that it is pointed in the direction of travel, and for left-hand welding of flat beads, reverse the right-hand procedure.

Figure 11



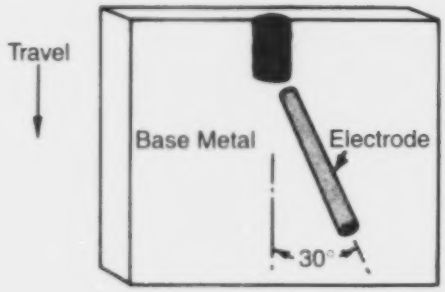
b. When welding in the horizontal position, angle the electrode 20° to 25° in the direction of travel.

Figure 12



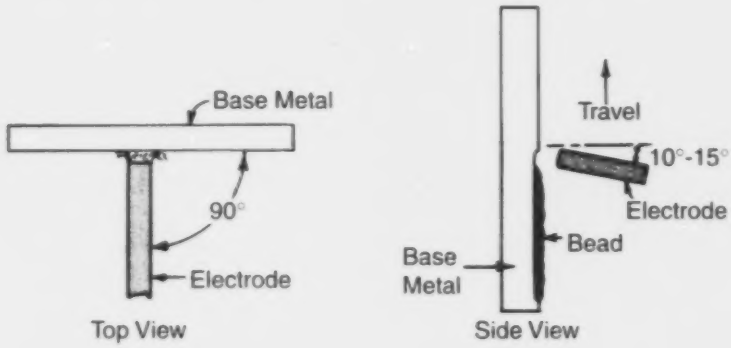
c. When welding in the vertical down position, point the electrode up at an angle of about 30° from the base metal.

Figure 13



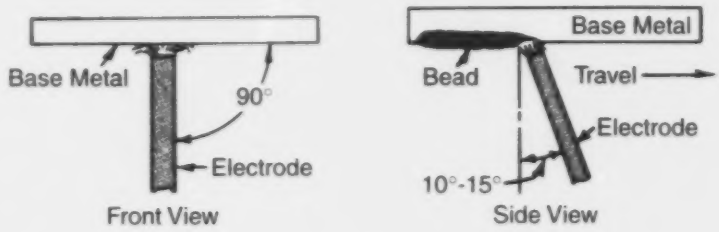
d. When welding in the vertical up position, hold the electrode 10° to 15° below perpendicular and at a 90° angle from the base metal.

Figure 14



e. When welding in the overhead position, hold the electrode perpendicular to the base metal at 90° and incline it 10° to 15° in the direction of travel.

Figure 15



Objective 18

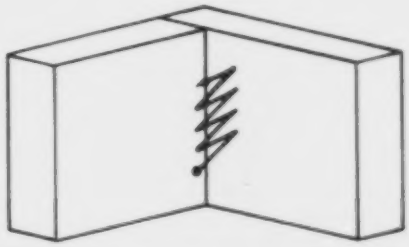
Bead running techniques and their procedures

a. **Drag**—Used with high-deposit, fast-fill electrodes and consists of lightly dragging the electrode tip along the base metal to force the molten filler metal uniformly out from under the electrode tip which in turn provides good penetration

Note: When perfected, the drag technique can produce welds so smooth and uniform they look as if they were machine made.

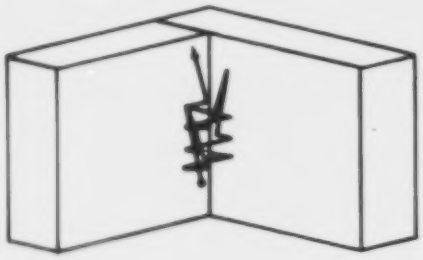
b. **Whipping**—Used with fast-freeze electrodes to make stringer beads in all positions and on all types of joints, and consists of maintaining a short arc when in the crater and a long arc as the electrode is drawn out of the crater so the molten pool will stay small and allow the filler metal to freeze quickly so the metal does not spill through the joint.

Figure 16



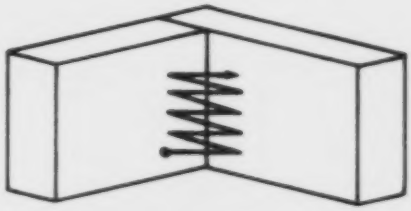
c. **Whipping with slight weave in crater**—Can be used with fast-freeze electrodes to make the first pass on vertical fillet and V-groove butt welds

Figure 17



d. **Side-to-side weave**—Used with all types of electrodes to make fill passes on vertical fillet and V-groove butt welds, and also sometimes used with fill-freeze and low-hydrogen electrodes to make the first pass on these joints

Figure 18



e. **Triangular weave**—Used with fill-freeze and low-hydrogen electrodes to make the first pass on vertical fillet and V-groove butt welds because it provides a larger weld than a side-to-side weave

Figure 19

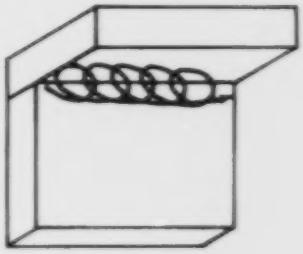
f. **Box weave**—Used with all types of electrodes to make the fill pass on vertical fillet and V-groove butt welds, and is similar to the side-to-side weave, but with a distinct pause and slight upward motion at each edge of the weld to assure complete crater fill-up and eliminate undercutting.

Figure 20

153

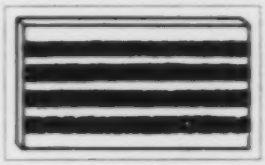
g. **Circular motion**—Used with all types of electrodes to make overhead welds

Figure 21



h. **Stringer bead**—A single, straight bead used with certain types of electrodes, and consists of a drag or whipping motion used in all welding positions

Figure 22

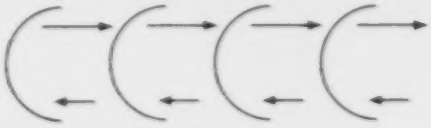


Courtesy of Lincoln Electric Company

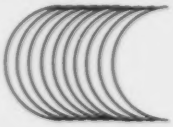
i. **Whip and pause**—A technique for laying down a bead by following the line of welding with a slight whipping action back from a weld puddle, a brief pause, and then a slighter whipping action back to the edge of the weld puddle to continue the bead.

Figure 23

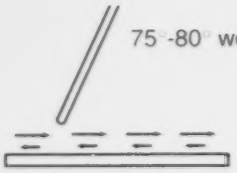
Whip out 1 electrode diameter and pause briefly to let the puddle freeze.



Whip back 1/2 electrode diameter to lay down more of the bead.



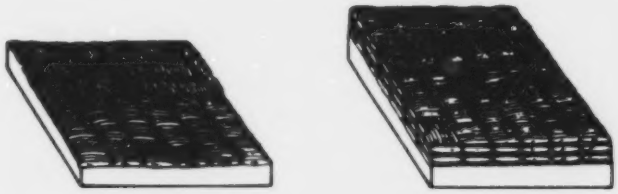
Final weld should be evenly rippled.



Stay in line with direction of travel

j. **Padding**—Used with all types of electrodes to build up metal surfaces with one or more layers of weld beads, and can be used on either fillet or curved surfaces as overlapping straight beads or overlapping weave beads

Figure 24



Courtesy of Lincoln Electric Company.

Objective 19

Technique for stopping and restarting an arc

a. Anticipate the point where the rod is going to be used up or where welding will stop.

b. Stop the forward motion of the electrode.

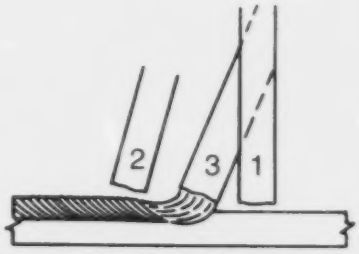
c. Gradually withdraw the electrode to break the arc.

d. Chip the slag off the end of the weld about 1/4" to 1/2" back.

e. Restart the arc about 1/2" in front of the forward end of the crater.

f. Move the electrode quickly back to the back crown of the crater and immediately resume welding in the direction of travel.

Figure 25



Courtesy of Lincoln Electric Company.

g. If the stop/restart procedure is properly executed, any marks left by restarting the arc ahead of the crater will be covered as the weld bead is continued.

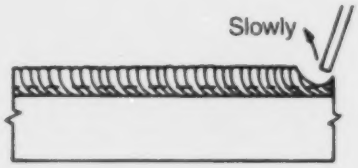
Objective 20

Techniques for filling a crater at the end of a weld

a. Option 1:

- Just before the bead reaches the end of the plate, shorten arc and break quickly. Make sure the motion is slow enough that the crater remains on top of the bead about 1/4″ to 1/2″ back from the end of the weld.

Figure 26

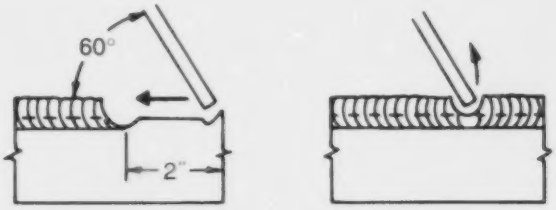


Courtesy of Lincoln Electric Company.

b. Option 2:

- Break the arc about 1″ or 2″ from the end of the weld by quickly shortening the arc and pulling it sideways out of the crater.
- Chip and remove slag from the end of the bead.
- Move to the end of the plate, restart the arc, and weld back toward the bead.
- Incline the electrode about 60° in the direction of travel.
- Weld back over the crater and stop the arc by pulling up and slightly backward as the two beads run together and the crater forms properly on top of the bead.

Figure 27



Courtesy of Lincoln Electric Company.

Objective 21

Guidelines for using feathered edges for tie-ins

a. To assure a good tie-in when restarting a bead or when starting from a tack weld, the tie-in point should always be chipped and brushed.

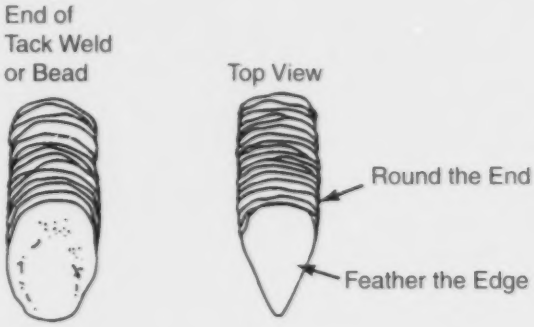
b. When a weld deposit is too large to make a normal tie-in, the end of the first bead or the end of the tack weld should be ground and feathered.

Figure 28

Side View

c. Grinding and feathering means using a hand grinder to smoothly round the sides near the end of the bead or tack weld, then grinding the end of the bead to a sloping, sharp edge.

Figure 29



d. Grinding and feathering sometimes called for in specifications, is used on some root passes in pipe welding, and is necessary on some V-groove welds.

Objective 22

Basic steps in joint preparation

a. Beveling requires putting angels on pieces of material so that when they are joined, the weld will get good penetration below the surface of the base metal.

b. Grinding requires the use of an abrasive device, usually a portable grinder, to remove metal or slag from the weld area.

Note: Although grinding may be used to bevel plates, it is mostly used to clean slag off a weld area after cutting or welding and for grinding and feathering edges for tie-ins.

157

Objective 23

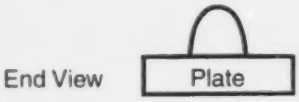
Good and bad welds and their characteristics

a. Current, voltage, and speed normal—Smooth well-formed bead with no undercutting, overlapping, or piling of slag

Figure 30

b. Current low—Poor penetration, slow progress, excessive piling of weld metal, and slag inclusion

Figure 31



c. Current high—Excessive spatter and undercutting of weld joints

Figure 32

d. Voltage high—Poor penetration with flat bead, weld zone not shielded

Figure 33

e. Voltage low—Poor penetration and humped bead

Figure 34

f. Speed slow—Excessive heat and weld metal reinforcement leading to unnecessary distortion of joint

Figure 35

g. Speed fast—Irregular bead, poor penetration, undercut, and not enough weld metal in joint, causing a weak joint

Figure 36

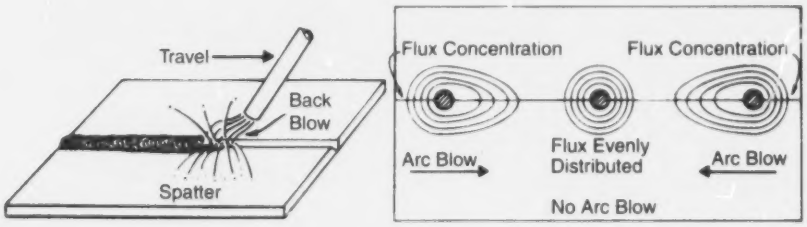
Objective 24

Causes of and remedies for arc blow

a. Arc blow is caused when magnetic forces present in DC build up lines of magnetism around the arc and cause the arc to blow wildly forward, back, or to one side, and spatter badly.

b. Arc blow can be caused by high amperage, and the major problem areas are thick plates, corners, deep grooves, and the start and finish of joints.

Figure 37



Courtesy of Lincoln Electric Company.

c. Remedies for arc blow include:

- Reduce current or switch polarity.
- Change current to AC.
- Change location of the ground clamp.
- Reverse direction of weld or reverse angle of weld bead.
- Maintain a short arc.

Objective 25

Causes of and remedies for pinholes and porosity

a. Both pinholes and porosity can be caused when arc length is too long and travel speed is too fast.

b. Other causes of pinholes and porosity are faulty electrodes, incorrect polarity, surface conditions of the base metal, or high sulphur and other impurities.

c. Remedies for pinholes and porosity include using a shorter arc length and keeping the puddle molten for a longer period so that the gases may boil out before the metal freezes.

d. Other remedies include using dry electrodes and cleaning the surfaces of base metals.

Objective 26

Causes of and remedies for undercutting

a. Undercutting is usually caused by too high a current or too long an arc length.

b. Undercutting can also be caused by improper rod angle manipulation or too fast a welding speed.

c. Remedies for undercutting include reducing the current and shortening the arc length.

d. Other remedies would be to use a smaller diameter electrode or change the electrode angle so that the force of the arc will help fill the undercut.

Objective 27

Causes of and remedies for weld spatter

a. Weld spatter is caused by too high a current or too long an arc length.

b. The remedies for weld spatter are to reduce current and shorten the arc length.

Objective 28

Causes of and remedies for incomplete penetration

a. Incomplete penetration can be caused by a faulty joint design, but can also be caused by insufficient welding current, too large an electrode, or too fast a welding speed.

b. One remedy for incomplete penetration is to check the joint carefully, including the root opening, root face dimension, and the groove face angle.

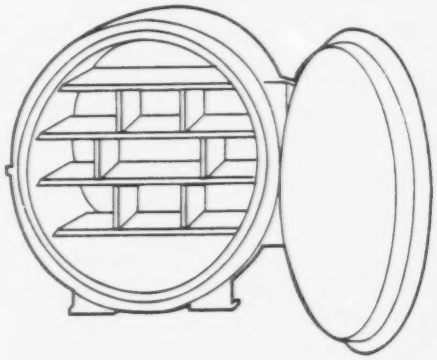
c. If the joint is not faulty, other remedies include increasing the weld current, reducing welding speed, and using a smaller diameter electrode.

Objective 31

Electrode drying ovens

a. Because moisture can change the chemical composition of some flux-covered electrodes, certain electrodes need to be stored in drying ovens and sometimes reconditioned or rebaked in a drying oven.

Figure 53



Type (AWS)	Air Conditioning Storage Before Opening RH = Relative Humidity	Dry Rod Oven Holding After Opening	After Exposure to Moisture a Sufficient Time to Affect Weld Quality	
			Recondition Prog. 01	Rebake Step. 01
CELLULOSE EXX10 EXX11 EXX20 EXX30 **TITANIA** EXX12 EXX13	70°F-110°F (21°C-43°C) 50% MAX RH	NOT RECOM-MENDED	NOT RECOMMENDED	NOT RECOMMENDED
IRON POWDER-ILS EXX14 EXX24 EXX27	70°F-110°F (21°C-43°C) 50% MAX RH	110°F-175°F (43°C-79°C)	1 HOUR @ 250°F-300°F (121°C-149°C) 1 TO 2 HOUR TOTAL	1 TO 1 HOUR @ 350°F (177°C)
IRON POWDER-LO-HYDROGEN EXX16 EXX26 **LO-HYDROGEN** EXX15 EXX16 **LO-HYDROGEN-HI-TENSILE** EXXX15 EXXX16 EXXX18	70°F-110°F (21°C-43°C) 50% MAX RH	250°F-350°F (121°C-177°C)	1 HOUR @ 300°F-400°F (149°C-204°C) 1½ HOUR TOTAL	½ HOUR @ 350°F-750°F (177°C-399°C)
STAINLESS EXXX-15 EXXX-16	40°F-120°F (4°C-49°C) 60% @ 10 RH	250°F-400°F (121°C-204°C)	1 HOUR @ 500°F (260°C)	NOT RECOMMENDED
INCONEL* MONEL* NICKEL HARD SURFACING	40°F-120°F (4°C-49°C) 60% @ 10 RH	150°F-200°F (66°C-93°C)	1 HOUR @ 425°F-475°F (218°C-247°C) 1 HOUR TOTAL	1 HOUR @ 500°F-600°F (260°C-316°C)
BRASSES BRONZES	40°F-120°F (4°C-49°C) 60% @ 10 RH	150°F-250°F (66°C-121°C)	NOT RECOMMENDED	NOT RECOMMENDED
GRANULATED OR AGGLOM-ERATED FLUX	40°F-120°F (4°C-49°C) 60% @ 10 RH	200°F-400°F (93°C-149°C)	NOT RECOMMENDED	1 HOUR @ 400°F-600°F (204°C-316°C)
FLUX CORED WIRE EXXT1 EXXT2 EXXT5 EXXTG	40°F-120°F (4°C-49°C) 60% @ 10 RH	250°F-300°F (121°C-149°C)	300°F-350°F (149°C-177°C)	NOT RECOMMENDED

Courtesy of Phoenix Products Company, Inc.

b. Reconditioning or rebaking times should be as recommended by the drying oven manufacturer in relation to electrode type and relative humidity of storage area.

161

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Student Supplement 1—Electrode Selection Carbon and Low Alloy Steel

The following electrode selections are for the "Fast Freeze" or "Out of Position" group of electrodes. These are truly all-purpose electrodes for fabrication and maintenance welding.

Product Name	Description (Capable of x-ray quality welds)	AWS Class	Electrode Polarity	Sizes & Current Ranges (Amps) Electrodes are manufactured in those sizes for which current ranges are given					
				3/32"	1/8"	5/32"	3/16"	7/32"	1/4"
Fleetweld® 5P	The original brick red electrode. For dirty, rusty, painted or plated steel, that cannot be completely cleaned.	E6010	DC+	40-70	75-130	90-175	140-225	200-275	220-325(1)
Fleetweld 5P+	Complements 5P with faster striking, easier slag removal and improved grey coating.	E6010	DC+	40-70	65-130	90-175	140-225	---	---
Fleetweld 35	General all purpose AC electrode for sheet metal edge, corner & butt welds.	E6011	AC DC+	50-85 40-75	75-120 70-110	90-160 80-145	120-200 110-180	150-260 135-235	190-300 170-270
Fleetweld 35LS	Excellent low-slag task welding electrode. Also for vertical down stringer beads, large gaps, AC pipe welding and applications requiring an extra low silicon deposit. Good tacking electrode for Innersheld welding.	E6011	AC DC+	-- --	80-130 70-120	120-160 110-150	--- ---	--- ---	--- ---
Fleetweld 180	All position electrode recommended for general purpose AC welding.	E6011	AC DC+	40-90 40-80	60-120 55-110	115-150 105-135	--- ---	--- ---	--- ---
Fleetweld 22	Special electrode for welding roof decking to beams with	E6022	DC-	---	110-150	150-180	---	---	---
For Welding High Tensile Pipe									
Shield-Arc® 85	Vertical up or down welding on 1/2% Mo steels and x42 through X65 pipe.	E7010-A1	DC+	50-90	75-130	90-175	140-225	---	---
Shield-Arc HYP	Designed for vertical down on 5L or 5LX pipe, X52 through X65. Features minimum wagon tracks and almost no tendancy to fill or cover pass pin holes. Meets P1.	E7010-G	DC+	---	75-130	90-185	140-225	160-250	---
Shield-Arc HYP+	Designed for improved welding characteristics for vertical down, root, fill an dcap pass welding of API 5L-X52 through X65 high strength pipe.	E7010-P1	DC+	---	75-130	90-185	140-225	160-250	---
Shield-Arc 70+	For easy operation of vertical down passes on X56 through X70 pipe for steels containing up to .30% silicon or where an E8010-G electrode is required.	E8010-G	DC+	---	75-130	90-185	140-225	---	---
Shield-Arc 80	Similar to Shield-70+, with better impact properties.	E8010-G	DC+	---	75-130	90-185	140-225	160-250	---
Shield-Arc 90	Vertical down welding on X70-X80 pipe. Meets P1.	E9010-G	DC+			90-185	140-225	---	---

(1) Range for 5/16" size is 240-400 amps.

Courtesy Lincoln Electric Company

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"Fast-Fill" or "High Deposition" Group

Made especially for welding carbon and low alloy steels. Highest deposition rates of all electrodes. Flat, horizontal and slightly downhill (15° maximum) position only. Easy slag removal and smooth, ripple-free beads are flat or slightly convex with minimal spatter.

Product Name	Description	AWS Class	Electrode Polarity	Sizes & Current Ranges (Amps) — Electrodes are manufactured in those sizes for which current ranges are given					
				3/32"	1/8"	5/32"	3/16"	7/32"	1/4"
Jetweld® 1	Better impact properties, higher ductility, better slag control and better resistance to pock-marking than Jetweld 3.	E7024-1	AC DC±	65-120 60-110	115-175 (1) 100-160	180-240 160-215	240-300 220-280	300-380 270-340	340-440 320-400
Jetweld 3	Similar to Jetweld 1, with added advantages of better slag removal, faster follow and slightly higher deposition rate.	E7024	AC DC±	65-120 60-110	115-175 (1) 100-160	180-240 160-215	240-315 215-285	300-380 270-340	350-450 315-405
Jetweld 2	For flat deep groove joints requiring x-ray quality or high notch toughness. Excellent wash-in.	E6027	AC DC±	--- ---	--- ---	190-240 175-215	250-300 230-270	--- ---	350-450 315-405

"Fill-Freeze" or "High Speed" Group

Made especially for welding carbon steel. Operates in all positions, but most widely used downhill, horizontal or in the flat position. Ideal for irregular or short welds that change direction or position. Medium deposit rates and medium penetration. Appearance ranges from smooth and ripple-free to even with distinct ripples.

Product Name	Description	AWS Class	Electrode Polarity	Sizes & Current Ranges (Amps) — Electrodes are manufactured in those sizes for which current ranges are given					
				3/32"	1/8"	5/32"	3/16"	7/32"	1/4"
Fleetweld 7	For sheet metal or general purpose plate welding. Operates well in both AC and DC-.	E6012	DC- AC	--- ---	80-135 90-150	110-180 120-200	155-250 170-275	225-295 250-325	245-325 275-360
Fleetweld 37	Intended for sheet metal welding when superior bead appearance and easy operation are more important than speed.	E6013	AC DC±	75-105 (1) 70-95	110-150 100-135	160-200 145-180	205-235 190-235	--- ---	--- ---
Fleetweld 47	Iron powder content provides highest deposit rate and fastest speeds of this group. Excellent for short, irregular, poorly fit or downhill joints.	E7014	AC DC-	80-100 75-95	110-160 110-145	150-225 135-200	200-280 185-235	260-340 235-305	280-425 260-380

(1) Range for 5/64" Fleetweld 37 is 50-80 amps AC or 45-75 amps DC. 1/16" Fleetweld 37 is 20-45 amps AC or DC.

Courtesy Lincoln Electric Company

Low Hydrogen Group

Made especially for welding carbon and low alloy steel. For alloy steels that require 70,000 psi tensile strength deposits. These low hydrogen electrodes can produce dense, x-ray quality welds with excellent notch toughness and ductility. The E7018 electrodes have "Fill-Freeze" characteristics and the E7028 electrode has "Fast-Fill" characteristics.

Product Name	Description	AWS Class	Electrode Polarity	Sizes & Current Ranges (Amps) — Electrodes are manufactured in those sizes for which current ranges are given					
				3/32"	1/8"	5/32"	3/16"	7/32"	1/4"
Excaliber 7018	Exceptional operating characteristics. Its smooth, even burnoff make it the ideal choice for critical out-of-position applications.	E7018 H4R	DC+ AC	70-110 80-120	85-150 100-160	125-200 140-210	200-300 200-300	250-330 270-370	300-400 320-420
Excaliber 7018-1	All position, low hydrogen, moisture resistant manual electrodes with exceptional operating characteristics and superior impact properties.	E7018-1 H4R	DC+ AC	70-110 80-120	85-150 100-160	125-200 140-210	200-300 200-300	250-330 270-370	300-400 320-420
Jetweld® LH-70	General purpose electrode for all positions, with easy slag removal, high deposit rates, and good crack resistance.	E7018 H4R	DC+ AC	70-100 80-120	90-150 110-170	120-190 135-225	170-280 200-300	210-330 260-380	290-430 325-440
Jetweld LH-73	Excellent restrike and good AC all position handling. Well suited for low current AC operation.	E7018 H8	AC DC+	75-120 70-115	105-150 100-140	130-200 120-185	--- ---	--- ---	--- ---
Jetweld LH-75MR	Superior impact properties, high resistance to moisture pickup and good low current operation. Identification on electrode is E7018-1.	E7018-1 H4R	DC+ AC	70-110 80-110	95-160 100-170	120-190 135-225	180-270 210-290	250-330 270-370	--- ---
Jet-LH® 78 MR	Extra high tensile strength in the stress-relieved condition. Easy all position handling and excellent weld appearance.	E7018 H4R	DC+ AC	85-110 ---	110-160 120-170	130-200 140-230	180-270 210-290	250-330 270-370	300-400 325-420
Jetweld LH-3800	For high production, high deposit applications requiring low hydrogen quality. Best on flat fillets and deep groove joints.	E7028 H8	AC DC+	--- ---	--- ---	180-270 170-240	240-330 210-300	275-410 280-380	380-520 ---

Courtesy Lincoln Electric Company

Low Hydrogen, Low Alloy Steel Group

Made for welding low alloy steels that require specific mechanical or chemical properties of one of these electrodes. Specifically fo ruse in cryogenics, high temperature applications, And for x-ray quality requirements. These electrodes have Low Hydrogen "Fill-Freeze" operating characteristics similar to Jetweld LH-70.

Product Name	Description	AWS Class	Electrode Polarity	Sizes & Current Ranges (Amps) Electrodes are manufactured in those sizes for which current ranges are given					
				3/32"	1/8"	5/32"	3/16"	7/32"	1/4"
Jetweld LH-90 MR	Produces a 1-1/4% Cr, 1/2% Mo deposite required for high temperature, high pressure piping.	E8018-B2 H4R	DC+ AC	--- ---	110-150 120-170	130-190 140-225	180-270 210-290	--- ---	--- ---
Jet-LH 8018-B2 MR	Procudes a 1-1/4% Cr, 1/2% Mo deposit for welding power piping, tubes, boilers and castings when design temperatures exceed 850° (454°C).	E8018-B2 H4	DC+ AC	70-100 85-120	100-140 110-150	120-190 135-200	--- ---	--- ---	--- ---
Jet-LH 9018-B3 MR	Produes a 2-1/4% Cr, 1% Mo deposite for welding power piping, tubes, boilers and castings when design temperatures exceed 850° (454°C).	E9018-B3 H4	DC+ AC	70-100 85-120	100-140 110-150	120-190 135-200	--- ---	--- ---	--- ---
Jet-LH 8018-C1 MR	Best for low temperature alloys used in storage, piping and transport of liquid ammonia, propane, etc. Produces a 2-1/4% Ni deposit for notch toughness to 20 ft-lbs at -75°F (27J @ -59°C).	E8018-C1 H4	DC+ AC	--- ---	90-150 110-160	120-180 140-200	180-270 200-300	--- ---	250-350 300-400
Jet-LH 8018-C3 MR	General purpose welding many high strength alloys. Produces a 1% Ni deposit for good notch toughness down to -60°F (-51°C).	E8018-C3 H4R	DC+ AC	--- ---	110-150 120-170	130-190 140-225	180-270 210-290	250-330 270-370	300-400
Jetweld LH-110M MR	Capable of producing 110,000 psi tensile strength deposits needed for full strength welds on specific quenched and tempered steels.	E11018-M H4R	DC+ AC	70-110 80-110	90-155 100-170	120-190 135-225	160-280 200-310	190-310 240-350	230-360 290-410

Courtesy Lincoln Electric Company

Low Hydrogen "Pipe Welding" Group

Made for welding vertical down of single and multiple pass fillet and butt welds.

Product Name	Description	AWS Class	Electrode Polarity	Sizes & Current Ranges (Amps) Electrodes are manufactured in those sizes for which current ranges are given			
				2.5"	3.2"	4.0"	4.5"
LH-D80	Designed for vertical down welding of single and multiple pass fillet and butt welds.	E8018-G	DC+	80-110	125-155	170-215	200-260
LH-D90	Designed for vertical down welding of single and multiple pass fillet and butt welds.	E9018-G	DC+	80-110	125-155	170-215	200-260
LH-D100	Designed for vertical down welding of single and multiple pass fillet and butt welds.	E10018-G	DC+	80-110	125-155	170-215	200-260
Lincoln 16P	For vertical up pipeline welding, up to and including X65 Grade, where low hydrogen deposit is required.	E7016	DC+ AC	55-80 60-80	75-120 80-120	120-160 120-160	--- ---
Lincoln 18P	For vertical up fill and cap pipeline welding, up to and including X80 Grade, where low hydrogen deposit is required.	E8018-G	DC+ AC	--- ---	90-140 100-140	130-170 140-180	--- ---

Courtesy Lincoln Electric Company

Red Baron®

These electrodes have a distinctive red coating. This coating is uniquely formulated for outstanding resistance to moisture pick-up and starting porosity. Optimized for all-position welding.

Red Baron Product	Description	AWS Class	Electrode Polarity	Sizes & Current Ranges (Amps) Electrodes are manufactured in those sizes for which current ranges are given			
				3/32"	1/8"	5/32"	3/16"
308/308H MR	Can be used to weld 304, 304H and 38 and applications where creep resistenace is required.	E308-16 E308H-16	DC+ AC	40-70	60-100	90-140	120-185
308/308L MR	Similiar to 308/308H MR with slightly lower carbon level. For joining common austenitic stainless steels grades usuall referred to as "18-8" steels.	E308L-16					
309/309L MR	For joining more high alloyed austenitic stainless steels. Can also be used on "18-8" steels since it overmatches the corrosion resistance, if the weldment will not be exposed to temperatures above 1000°F (538°C).	E309-16 E309L-16					
310 MR	Very high alloy content. For Types 310S and 310H wrought and A743 Type CK-20 cast materials.	E310-16					
316/316L MR	Undiluted weld metal is designed to contain considerable ferrite, for maximum crack resistance in joining 316 and 316L stainless steels. Do not use on Type 316L joints in sevice for urea manufacture, as this environment will attack the ferrite.	E316-16 E316L-16					
347 MR	For Types 347 stainless and A743 and A744 Type C-8C cast steel. Niobium content prohibits carbide precipitation. The protection over and above the protection from the low carbon.	E347-16					
308/308L-V MR 309/309L-V MR 316/316L-V MR	These electrodes provide very similar alloy deposits and characteristics as listed above. Designed primarily for vertical down welding.	308-15, L-15 E309-15, L-15 E316-15, L-15	DC+	60-70	90-100	---	---

Courtesy Lincoln Electric Company

Blue Max®

The Blue Max AC-DC series of stainless steel electrodes is characterized by their distinctive blue coating and spray type metal transfer. These electrodes can be lightly

Blue Max Product	Description	AWS Class	Electrode Polarity	Sizes & Current Ranges (Amps) Electrodes are manufactured in those sizes for which current ranges are given			
				3/32"	1/8"	5/32"	3/16"
308/308L AC-DC	For joining common austenitic stainless steels graded usually referred to as "18-8" steels.	E308/308L-17	DC+ AC	40-80	75-110	95-150	130-200
309/309L AC-DC	For joining more high alloyed austenitic stainless steels. Can also be used on "18-8" steels since it overmatches the corrosion resistance, if the weldment will not be ex-posed to temperatures above 1000°F (538°C).	E309/309L-17	DC+ AC				
316/316L AC-DC	Undiluted weld metal is designed to contain consider-able ferrite, for maximum crack resistance in joining 316 and 316L stainless steels. Do not use on Type 316L joints in service for urea manufacture, as this environ-ment will attack the ferrite.	E316/316L-17	DC+ AC				
347 AC-DC	For Types 347 stainless and A743 and A744 Type C-8C cast steel. Noibium content prohibits carbide precipitation. The niobium found in this electrode provides added corrosion protection over and above the protection from the low carbon content.	E347-17	DC+ AC				
2100	Designed for "hard-to-weld" applications. Resistance to cracking, and high strength when joining steels that are normally difficult to weld.	---	DC+ AC	60-80	75-110	95-150	---

Courtesy Lincoln Electric Company

Unit Contents

Student Components

	Student Page
Learning Activities Sheet	3–3
Objective Sheet	3–5
Information Sheet	3–7
Student Supplement	
1—Hardfacing Electrode Selection	3–11
*Job Sheets	
1—Build a Pad on Mild Steel With a Hardfacing Electrode	153
2—Prepare and Hardface Simulated Bucket Teeth	157

*The Job Sheets are located in the Student Workbook.

176

Prerequisites:

Learning Activities Sheet

Student Name _____

Place a checkmark in the appropriate box as you complete each of the steps below.

❑ 1.	**Take**	Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.
❑ 2.	**Read**	Objective Sheet.
❑ 3.	**Study**	Information Sheet, Objectives 1 through 7.
❑ 4.	**View**	Video tapes as available.
❑ 5.	**Do**	Job Sheet 1, "Build a Pad on Mild Steel with a Hardfacing Electrode."
❑ 6.	**Stop**	Have instructor evaluate your completed job sheet. If the evaluation is satisfactory, continue per instructor's directions. If the evaluation is unsatisfactory, repeat the job sheet and have your instructor reevaluate.
❑ 7.	**Do**	Job Sheet 2, "Prepare and Hardface Simulated Bucket Teeth."
❑ 8.	**Stop**	Have instructor evaluate your completed job sheet. If the evaluation is satisfactory, continue per instructor's directions. If the evaluation is unsatisfactory, repeat the job sheet and have your instructor reevaluate.
❑ 9.	**Check**	With instructor for any additional assignments to be completed.
❑ 10.	**Do**	Additional assignments listed below.
❑ 11.	**Take**	Posttest provided by instructor. After test has been evaluated, follow instructor's recommendations.

_____

_____

❑ 12. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next learning activities sheet. If evaluation is not satisfactory, ask instructor for further instructions.

*Permission to duplicate this form is granted.

Objective Sheet

Unit Objective

After completing this unit, the student should be able to discuss the elements of hardfacing and the arc welding methods used for hardfacing. The student should also be able to build a pad on mild steel with a hardfacing electrode and prepare and hardface simulated bucket teeth. The student should demonstrate these competencies by completing the job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to hardfacing with their definitions.
2. Complete statements about the benefits of hardfacing.
3. Select true statements about the welding methods used for hardfacing.
4. Complete statements about advantages and limitations of manual electrode hardfacing.
5. Match types of wear with their characteristics.
6. Complete guidelines for applying weld deposits.
7. Select true statements about cautions for hardfacing ventilation safety.
8. Complete statements about heat treating cautions.
9. Select true statements about guidelines for heavy construction hardfacing.
10. Complete statements about hardness ratings for hardfacing electrodes.

*11. Build a pad on mild steel with a hardfacing electrode. (Job Sheet 1)

*12. Prepare and hardface simulated bucket teeth. (Job Sheet 2)

*The Job Sheets are located in the Student Workbook.

Information Sheet

Objective 1

Terms and definitions

a. **Base metal**—The type of metal in a part selected for hardfacing and the primary consideration for selecting build-up material for hardfacing

b. **Build-up**—The step in hardfacing where selected weld metal is applied in a layer or layers on a part selected for hardfacing

c. **Buttering**—Sometimes a preliminary step in hardfacing because it is a process that dilutes the carbon and alloy content of base metal before build-up begins

d. **Hardfacing**—The final layer of metal deposited after build-up in the hardfacing process

Objective 2

Benefits of hardfacing

a. Hardfacing is a low-cost method of depositing wear-resistant surfaces onto metal components to extend their service life and avoid high-cost replacement parts.

b. Although hardfacing is primarily used to restore worn parts to a serviceable condition, hardfacing is also applied to new components before they are placed into service to extend service life.

Objective 3

Welding methods used for hardfacing

a. Semiautomatic welding uses wire feeders and self-shielded, flux-cored electrodes for depositions rates greater than those achieved with manual welding.

b. Automatic welding requires a great amount of initial setup, but provides the highest deposition rate for maximum productivity.

c. Manual electrode hardfacing is recommended for irregular shapes, out-of-position welding, low-volume applications, and many small parts.

Objective 4

Advantages and limitations of manual electrode hardfacing

a. The greatest advantage of manual electrode hardfacing is its versatility because it can handle nearly any shape or contour.

b. Another advantage of manual hardfacing is that it can be used on small or large parts in all positions although positioning for downhand welding is recommended.

c. One limitation with manual hardfacing is that labor costs are relatively high because deposition rates are lower than with mechanized processes.

d. Another limitation with manual hardfacing is the prospect that human error could result in poor welding quality or a rough surface.

Objective 5

Types of wear and their characteristics

a. **Metal-to-metal**—Wear from steel parts rolling or sliding against each other with little or no lubrication, conditions in sprockets and gear teeth

b. **Severe impact**—Wear from severe pounding which tends to squash, gouge and check the surface, conditions found in much construction equipment

c. **Abrasion plus impact**—Wear from gritty materials accompanied by heaving pounding which tends to chip or crack as well as grind away the surface, conditions found in bucket and dump blades

d. **Severe abrasion**—Wear from gritty materials which grind or erode the surface and often accompanied by heavy compression or moderate impact, conditions found in crusher rolls and conveyor screws

e. **Metal-to-earth abrasion**—Wear from earth-like materials like sand, grit and pebbles and accompanied by moderate impact from pounding, conditions found in scraper blades and paddles

f. **Corrosion**—Wear caused by chemical exposure like conditions found in valve faces and seats

g. **Combination wear**—The combination of two or more of the previously listed phenomena; combination wear in most or at least many cases is the effective wear on a component

Objective 6

Guidelines for applying weld deposits

a. All hardfacing should start with cleaning to remove rust, dirt, grease, oil and other contaminants from the surfaces to be built up and hardfaced.

b. Surfaces to be hardfaced require preparation especially if badly cracked or deformed, and the preparation may require machine grinding or carbon arc gouging.

c. Avoid excessive build-up of hardfacing deposits or they may crack and break off rapidly in service and in cases where thick deposits are required, use appropriate build-up materials before hardfacing.

d. The combination of alloy content, carbon content, massive size and part rigidity creates a necessity to preheat in many build-up and hardfacing operations.

e. A large job may require reheating to keep interpass temperature at a proper level, and when a job is interrupted for a length of time, like a lunch break, preheat the base metal again.

f. A small amount of distortion can destroy the usability of some parts so rigid bracing, prebending or other distortion control techniques may be required.

Objective 7

Cautions for hardfacing ventilation safety

a. Fumes from the normal use of certain hardfacing welding products contain significant quantities of components such as chromium and manganese which can lower the maximum exposure guideline for general welding fumes.

b. Hardfacing indoors requires a good exhaust system and in some cases may require special ventilation depending on the electrode used.

c. Hardfacing outdoors requires careful attention to wind-blow fumes and keeping your head away from dangerous fumes.

d. In other outdoor hardfacing where an operator may be working in a confined space such as a tank or enclosed area, always WEAR A RESPIRATOR!

Objective 8

Heat treating cautions

a. Manganese steel becomes brittle if overheated; while 100°F to 200°F may be required, do not allow interpass temperature to exceed 500°F.

b. Some alloy steel components require a specific heat treatment to perform properly in service; this must be considered in preheating and hardfacing and may require contacting the part manufacturer.

Example: Some truck beds have been heat treated for special service characteristics. When you observe a "Do Not Weld" sign on a truck bed or any other equipment, do not attempt heat treatment.

Objective 9

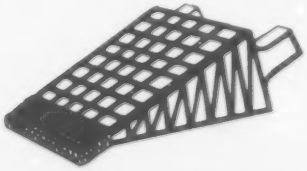
Guidelines for heavy construction hardfacing

a. Whether removing earth cover prior to coal or mineral excavation or building highways or other construction projects, power shovel buckets and bucket teeth are subjected to varying degrees of abrasion and impact which will indicate the type of hardfacing materials to be used.

Example: Some types of sandy soils are very abrasive but do not provide much in the way of impact wear, but rocky soils are not only abrasive but do provide moderate to heavy impact wear.

b. General rules for hardfacing bucket teeth call for hardfacing the top of the leading edge of the bucket lip solid from the tip back approximately 2"; the balance of the beads should be applied according to type of service as demonstrated in the following chart.

Figure 1



Courtesy Lincoln Electric Company

For dirt, clay or sand	For rock or slag	For both rock and sand or dirt
Place beads perpendicular to material flow	Place beads parallel to material flow	Use waffle pattern

Note: Be sure to use hardfacing materials comparable to those recommended for bucket teeth.

Objective 10

Hardness ratings for hardfacing electrodes

a. Generally speaking, hardfacing or surfacing electrodes are rated on a Rockwell C hardness scale of 15 to 64 with 15 being least hard and 65 being hardest.

Note: Some hardfacing electrodes may range as high as 70, but most hardfacing electrodes fall in the 15 to 65 range.

b. The AWS classification for surfacing electrodes is a general classification of A5.13; 2000; other AWS classifications like E6010 relate an electrode to properties such as tensile strength but surfacing electrodes have no tensile strength and should not be used for joining metals.

Caution: There are very few hardfacing electrodes that can be used to join metals so the best rule to remember is: Never attempt to join metals with hardfacing electrodes!

c. Hardness factors are critical to filler metal selection and must be suitable for the metal in the part being hardfaced.

Note: Student Supplement 1 presents electrode selections for specific hardness and for specific types of wear.

d. Hardfacing should be suitable for machining if machining is required to obtain contour or other operating characteristics, and this requires care because some hardfacing electrodes leave deposits so hard they cannot be machined.

Student Supplement 1—Hardfacing Electrode Selection

Build-Up

Wearshield® Product	Description	Hardness Rockwell C (as deposited)	Electrode Polarity	Sizes & Current Ranges (Amps) Electrodes are manufactured in those sizes for which current ranges are given			
				1/8"	5/32"	3/16"	1/4"
BU	For carbon and low allow steels. Builds up worn steel parts to produce tough, forgeable, machinable surfaces of moderate hardness.	23-28	DC+ AC	--- ---	145-210 155-225	180-280 200-290	230-360 255-375
BU-30	Moderate hardness to resist shock and abrasion. Used as final overlay on parts which must be machined or forged. For mild, medium carbon, low alloy and high tensile steels.	31-28	DC+ AC	90-130 100-140	140-180 150-200	170-220 190-240	--- ---

Metal-to-Metal Wear

Wearshield® Product	Description	Hardness Rockwell C (as deposited)	Electrode Polarity	Sizes & Current Ranges (Amps) Electrodes are manufactured in those sizes for which current ranges are given				
				3/32"	1/8"	5/32"	3/16"	1/4"
MM	Martensitic desposit. Heat treatable weld metal. Can be tempered, annealed. Carbon and low alloy steels.	52-58	DC+ AC	--- ---	90-130	140-180	170-220	---
MI	Provides wear-resistant surface of martensite, with substantial retained austenite. Resists metal-to-metal wear, impact, mild abrasion. Carbon and low alloy steels.	50-58	DC+ AC	---	70-120	110-150	150-200	225-275
T&D	Deposit similar to Type M-1 tool steel. Air hardening. Resists metal-to-metal wear up to 1000° (538°C).	58-65	DC+ AC	90-130 100-140	110-130	130-160	---	---
C21	Deposit of esstentially sold solution cobalt-chromium-molybdenum-nickel alloy. Principal application is resisting.	25	DC+ AC	---	85-110	100-140	140-180	---
C21-Bare	Metal-to-metal wear, in a severe corrosion environment and/or at high temperature. C-21B is an uncoated rod for gas tungsten arc hardfacing.	25	Oxy Fuel	---	N/A	N/A	N/A	N/A

Courtesy Lincoln Electric Company

Severe Abrasion

Wearshield® Product	Description	Hardness Rockwell C (as deposited)	Electrode Polarity	Sizes & Current Ranges (Amps) Electrodes are manufactured in those sizes for which current ranges are given			
				1/8"	5/32"	3/16"	1/4"
60	Excellent abrasion resistance. Bonds to carbon, low alloy, stainless, manganese steel. Limited to 2 layers. Build-up with BU, Mangjet or 15CrMn.	60-65	DC± AC	100-140 110-150	130-180 110-150	210-250 230-270	--- ---
70	Resists severe abrasion up to 1400°F (760°C). Use with mild, low alloy, stainless and austenitic manganese steels. Limited to 2 layers.	69	DC± AC	125-165 120-160	160-230 160-210	220-300 230-300	--- ---
C1 C1 Bare	Provides a near-eutectic deposit of cobalt alloy and carbides. Resists abrasion at high temperatures.	50	DC+/AC	85-110	100-140	140-180	---
		50	Oxy Fuel	N/A	N/A	N/A	---
CC Bare Cast Chrome Carbide	Applied Oxy-Fuel on tillage tools. Produces high carbon chrome deposits with excellent abrasion resistance and low coefficient of friction-deposits.	56-62	Oxy Fuel	---	---	---	N/A

Metal-to-Earth Wear

Wearshield® Product	Description	Hardness Rockwell C (as deposited)	Electrode Polarity	Sizes & Current Ranges (Amps) Electrodes are manufactured in those sizes for which current ranges are given		
				1/8"	5/32"	3/16"
ME	Use on carbon and low alloy steels, cast iron, austenitic manganese and austenitic stainless steels. Use BU or 15CrMn for preliminary layer(s).	49-59	DC± AC	125-175 130-170	175-250 180-220	220-300 230-270

Courtesy Lincoln Electric Company

Severe Impact

Wearshield® Product	Description	Hardness Rockwell C (as deposited)	Electrode Polarity	Sizes & Current Ranges (Amps) Electrodes are manufactured in those sizes for which current ranges are given			
				1/8"	5/32"	3/16"	1/4"
Mangjet®	For building up austenitic manganese steel and cladding carbon steel. Pounding in service, work hardens the deposit to develop maximum hardness and abrasion resistance (40 - 50R_C).	17-20	DC+ AC	-- ---	120-180 125-210	160-260 175-275	200-350 225-375
Frogmang®	Designed for building-up frogs and crossing diamonds in the railroad industry. The electrode's higher strength can easily handle the increased weight of railroad cars, reducing the need for repeated repairs. Work hardens to 45-55 Rc.	20-30	DC+ AC	100-140 120-150	140-075 150-180	125-225 185-213	235-280 235-270
15CrMn	For austenitic manganese steel to resist severe impact or gouging even in single layer or carbon steel, with excellent crack resistance. Joining of manganese steel to itself or carbon or low alloy steel. Work hardens to 45-55 Rc	18-24	DC+ AC	140-160	190-210	220-250	---

Abrasion Plus Impact

Wearshield® Product	Description	Hardness Rockwell C (as deposited)	Electrode Polarity	Sizes & Current Ranges (Amps) Electrodes are manufactured in those sizes for which current ranges are given			
				1/8"	5/32"	3/16"	1/4"
ABR	Versatile electrode producing good resistance to abrasion, impact. Good hot-forging properties. Hardness will vary depending on cooling rate	28-53	DC± AC	40-150 50-165	75-200 80-220	110-250 120-275	150-375 165-410
44	Moderate hardness to resist abrasion under impact at temperatures up to 1100°(593°C). Good spalling resistance on two or more layers.	42-48	DC+ AC	120-160 130-160	150-220 180-220	190-270 220-260	--- ---
C6	Provides a deposit of primary solid solution cobalt alloy with eutectic carbides. Resists high temperature abrasion with impact or metal-to-metal wear.	40	DC+ AC	85-110	100-140	140-180	---
C6 Bare	C6 Bare is an uncoated rod for gas tungsten arc hardfacing.	40	Oxy Fuel	---	---	---	---
SM 80	Designed specifically for surfacing and resurfacing crushing rolls of the sugar cane industry.	45-60	DC± AC	--- ---	150-240 160-250	210-270 220-280	--- ---

Courtesy Lincoln Electric Company

Unit Contents

Student Components

Student Page

Learning Activities Sheet 4–3

Objective Sheet 4–5

Information Sheet 4–7

*Job Sheets

1—Gouge a Piece of Mild Steel With the Carbon Arc Arc Cutting—Air Process 163
2—Backgouge a Piece of Mild Steel Beveled Plate With the Carbon Arc Cutting—Air Process 167

*The Job Sheets are located in the Student Workbook.

Prerequisites:
None

Learning Activities Sheet

Student Name _____

Place a checkmark in the appropriate box as you complete each of the steps below.

❑ 1.	**Take**	Pretest provided by instructor. After test has been evaluated, follow instructor's recommendations.
❑ 2.	**Read**	Objective Sheet.
❑ 3.	**Study**	Information Sheet, Objectives 1 through 10.
❑ 4.	**View**	Videotapes as available.
❑ 5.	**Observe**	Demonstration of procedures to be used in completing Job Sheet 1.
❑ 6.	**Do**	Job Sheet 1, "Gouge a Piece of Mild Steel With the Carbon Arc Cutting—Air Process."
❑ 7.	**Stop**	Have instructor evaluate your performance and if the evaluation is satisfactory, continue to step 8. If the evaluation is not satisfactory, study the procedure outlined in Job Sheet 1 and repeat step 6.
❑ 8.	**Study**	Information Sheet, Objective 11.
❑ 9.	**Observe**	Demonstration of procedures to be used in completing Job Sheet 2.
❑ 10.	**Do**	Job Sheet 2, "Backgouge a Piece of Mild Steel Beveled Plate With the Carbon Arc Cutting—Air Process."
❑ 11.	**Stop**	Have instructor evaluate your performance. If the evaluation is satisfactory, continued to step 12. If the performance is not satisfactory, study the procedure outlined in Job Sheet 2 and repeat step 10.
❑ 12.	**Check**	With instructor for any additional assignments to be completed.

❑ 13. **Do** Additional assignments listed below.

_____

_____

❑ 14. **Take** Posttest provided by instructor. After the test has been evaluated, follow instructor's recommendations.

❑ 15. **Stop** Have instructor evaluate your unit performance. If the evaluation is satisfactory, proceed to next Learning Activities Sheet. If evaluation is not satisfactory, ask instructor for further instructions.

*Permission to duplicate this form is granted.

152

Objective Sheet

Unit Objective

After completing this unit, the student should be able to set up a carbon arc cutting—air system, gouge a piece of mild steel and backgouge a piece of mild steel beveled plate. The student should demonstrate these competencies by completing the job sheets and by scoring a minimum of 85 percent on the written test.

Specific Objectives

After completing this unit, the student should be able to:

1. Match terms related to CAC—A with their definitions.
2. Select true statements concerning principles of carbon arc cutting—air.
3. Select true statements about CAC—A power sources.
4. Match types of CAC—A electrodes with their characteristics.
5. Match CAC—A electrode shapes with their uses.
6. Match CAC—A electrode angles with their applications.
7. Complete statements about amperage selection for gouging.
8. Complete statements about air pressure and how it affects gouging.
9. Complete statements about travel speed and how it affects gouging.
10. Match gouging techniques with their procedures.
11. Select true statements about when to use backgouging.
12. Gouge a piece of mild steel with the carbon arc cutting—air process. (Job Sheet 1)
13. Backgouge a piece of mild steel beveled plate with the carbon arc cutting—air process. (Job Sheet 2)

*The Job Sheets are located in the Student Workbook.

Information Sheet

Objective 1

Terms and definitions

a. **Arc cutting**—A group of cutting processes that melt the base metal with the break of an arc between the electrode and the base metal; arc cutting is a variation of the process that produces a gouge in a base metal instead of totally cutting it

b. **Backgouging**—The removal of weld metal and base metal from the other side of a partially welded joint to facilitate complete fusion and complete joint penetration upon subsequent welding from that side

c. **Back weld**—A weld at the back of a single groove weld

d. **Gouging**—The form of a bevel or groove by material removal

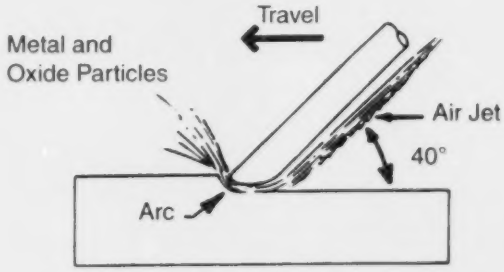
Objective 2

Principles of carbon arc cutting—air (CAC—A)

a. CAC—A is a cutting process that cuts or gouges metal by using an electric arc between a carbon electrode and a base metal.

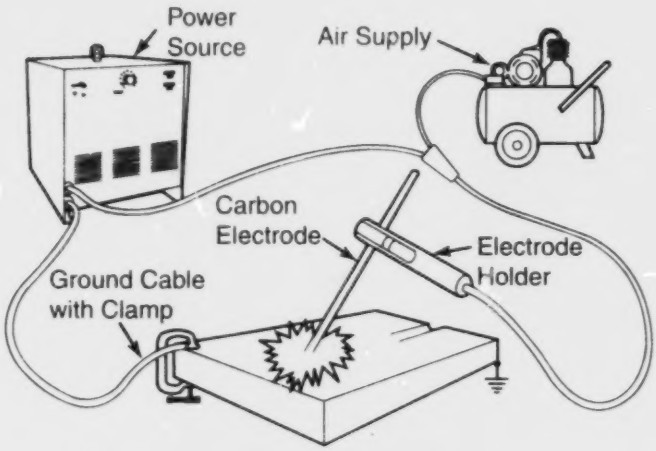
b. As the arc melts the base metal, a controlled stream of compressed air is directed at the arc to remove molten metal to make a complete cut or produce a groove.

Figure 1



c. Equipment needed for CAC—A includes a power supply, ground cable with clamp, carbon electrodes, an air carbon arc torch, and a supply of compressed air.

Figure 2



Courtesy of Union Carbide Corporation, Linde Division

Objective 3

CAC—A power sources

a. Standard power sources for arc welding can be used for CAC—A, but an opening circuit voltage of at least 60 volts is required.

Type of Current	Type of Power Source	Remarks
DC	Variable-voltage, motor-generator, rectifier, or resistor-grid equipment	Recommended for all electrode sizes.
DC	Constant-voltage motor-generator or rectifier	Recommended only for electrodes above 1/4" diameter.
AC	Transformer	Should be used only with AC electrodes.
AC-DC	Rectifier	DC supplied by three-phase transformer-rectifier is satisfactory. DC from single-phase source not recommended. AC from AC-DC power source is satisfactory if AC electrodes are used.

Courtesy Union Carbide Corporation, Linde Division

b. Air pressure required to make a cut depends on the diameter of the carbon electrode, and air pressures usually range from a minimum of 40 psi to 80 psi and above.

Maximum Electrode Size (in.)	Application	Pressure (psi)	Consumption (cfm)
1/4	Intermittent-duty, manual torch	40	3
1/4	Intermittent-duty, manual torch	80	9
3/8	General-purpose	80	16
3/4	Heavy-duty	80	29
5/8	Semiautomatic mechanized torch	80	25

Courtesy Union Carbide Corporation, Linde Division

Objective 4

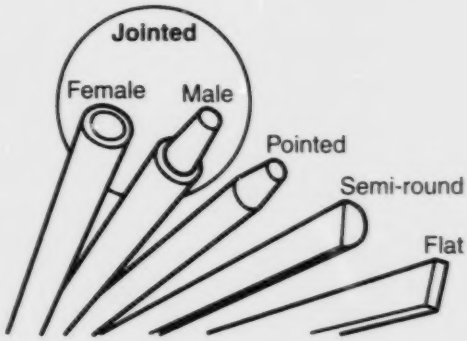
Types of CAC—A electrodes and their characteristics

a. Copper-coated—Made of graphite (carbon) for DC operation in sizes from 5/32″ to 1″

b. Flux-coated steel—Used for cutting or gouging high-purity copper or cast iron and available with a 1/4″ diameter and 18″ long

c. Graphite—Electrode has no copper coating, which tends to make the electrode "pencil" or cause a gradual decrease in the size of a groove

Figure 3



Material	Electrode	Power
Steel	DC AC	DCRP AC
Stainless Steel	DC AC	DCRP ACAC
Iron (cast iron, ductile iron, malleable iron)	AC DC	AC or DCSP DCRP (high-amperage)
Copper Alloys	AC DC	AC or DCSP DCRP
Nickel Alloys	AC	AC or DCSP

Courtesy of Union Carbide Corporation, Linde Division.

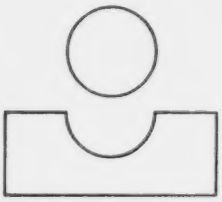
Objective 5

CAC—A electrode shapes and their uses

Note: Illustrations courtesy of Union Carbide Corporation, Linde Division.

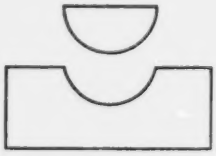
a. A round electrode is used to gouge a U groove.

Figure 4



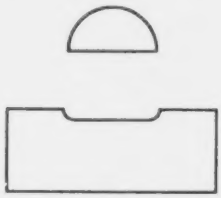
b. A semi-round electrode can also be used to gouge a U groove.

Figure 5



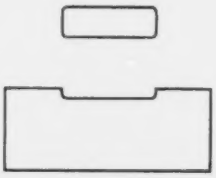
c. A semi-round electrode can also be turned to gouge a flat groove.

Figure 6



d. A flat electrode is used to gouge a flat groove.

Figure 7



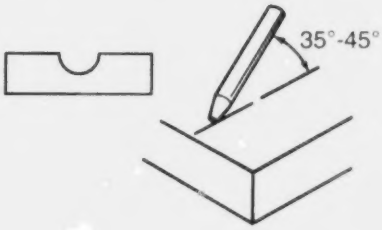
Objective 6

CAC—A electrode angles and their applications

Note: Illustrations courtesy of Union Carbide Corporation, Linde Division.

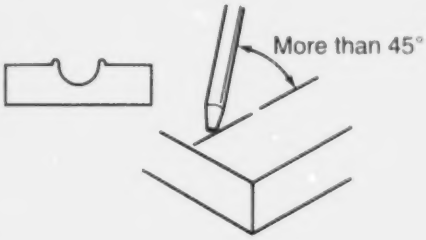
a. 35° to 45° between electrode and work—The preferred angle for gouging

Figure 8



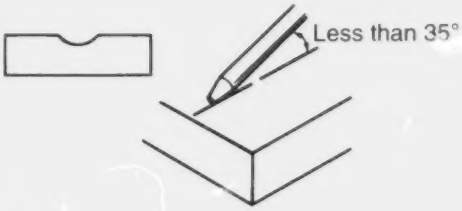
b. More than 45° between electrode and work—A nonpreferred angle that is higher and causes the groove to cut deeper into the base metal and impair metal removal

Figure 9



c. Less than 35° between electrode and work—A nonpreferred angle that is lower and causes the groove not to cut as deeply into the base metal

Figure 10



Objective 7

Amperage selection for gouging

Note: Illustrations courtesy of Union Carbide Corporation, Linde Division.

a. Amperage should be selected according to power source and electrode size.

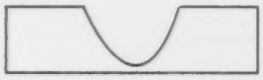
Type of Electrode and Power	Maximum and Minimum Current (amp)					
	Electrode Size (in.)					
	5/32	3/16	1/4	5/16	3/8	1/2
DC Electrodes, DCRP Power	90-150	150-200	200-400	250-450	350-600	600-1000
AC Electrodes, AC Power	--	150-200	200-300	--	300-500	400-600
AC Electrodes, DCSP Power	--	150-180	200-250	--	300-400	400-500

b. When amperage is lower than recommended, the groove will retain a U shape, but it will be shallow.

Figure 11

c. When the amperage is higher than recommended, approximately 15 percent higher, the groove will change from a U to a V shape.

Figure 12



d. When amperage is set to recommended, the groove will have a uniform U shape with good depth.

Figure 13

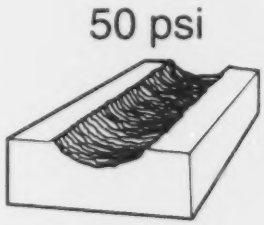
Objective 8

Air pressure and how it affects gouging

Note: Illustrations courtesy of Union Carbide Corporation, Linde Division.

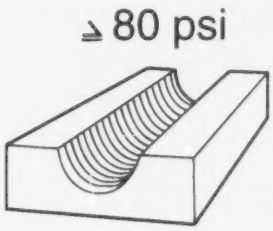
a. Low air pressure tends to produce an irregular surface and edge.

Figure 14



b. Correct air pressure allows for slag-free cuts.

Figure 15



Objective 9

Travel speed and how it affects gouging

Note: Illustrations courtesy of Union Carbide Corporation, Linde Division.

a. Slow travel speed generates more heat input into the base metal and produces a deeper groove.

Figure 16

b. High travel speed decreases metal removal, and as travel speed increases, metal removal decreases accordingly.

Figure 17

c. Correct travel speed produces a groove depth that is approximately half the diameter of the electrode.

Figure 18

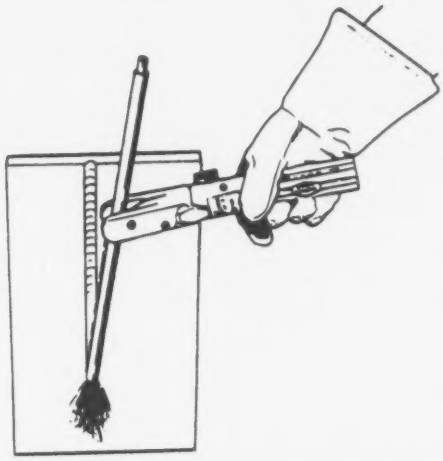
201

Objective 10

Techniques for gouging and their procedures

a. Vertical gouging should be done in the vertical down direction to allow for safe removal of molten metal.

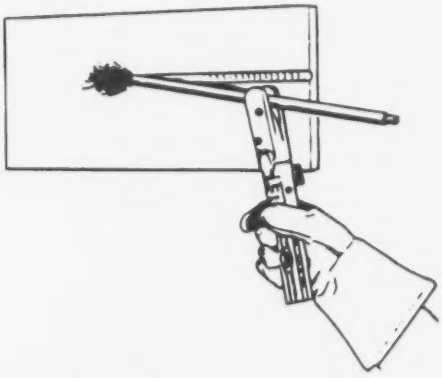
Figure 19



Courtesy of Union Carbide Corporation, Linde Division

b. Horizontal gouging may be done left or right, but airstream must remain behind the electrode with respect to the direction of travel.

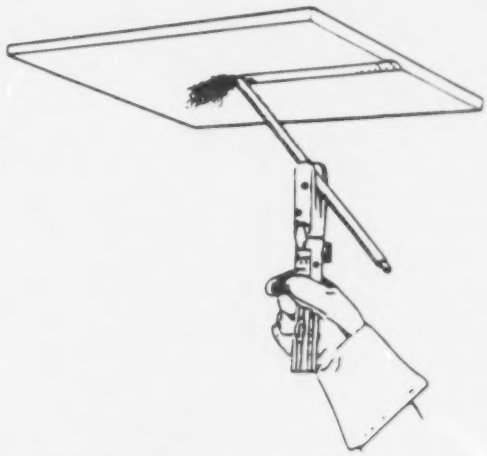
Figure 20



Courtesy of Union Carbide Corporation, Linde Division

c. Overhead gouging requires that the electrode be perpendicular to the base metal and angled so that molten metal will not drop on the operator.

Figure 21



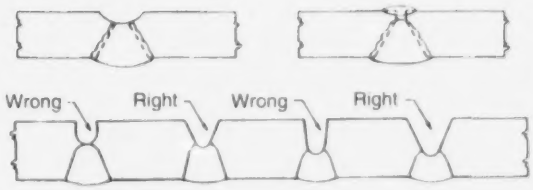
Courtesy of Union Carbide Corporation, Linde Division

Objective 11

When to use backgouging

a. To consistently complete fusion when welding a plate, backgouging is required on virtually all joints except bevel joints with feathered edges.

Figure 22



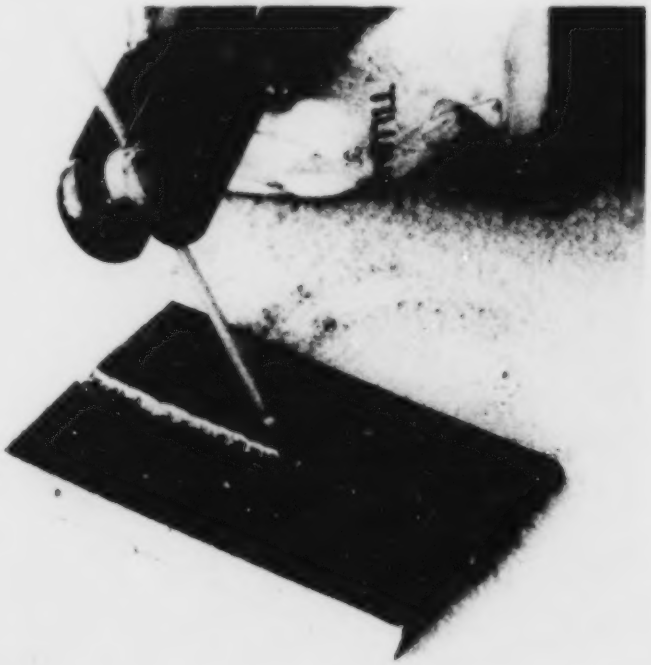
Courtesy Lincoln Electric Company

b. Although grinding and chipping can accomplish gouging, backgouging with an electrode is generally the quickest and most economical, and when properly accomplished, can leave an ideal contour for finishing a weld.

203

c. The major rule of backgouging is that the gouge should be deep enought to expose sound weld metal.

Figure 23



d. Backgouging may need to be followed by back-chipping to expose sound weld metal and provide complete accessibility for the correct electrode angle.

e. Cutting goggles do not provide enough protection for backgouging, so always wear a welding helmet, and because backgouging can be a very noisy process, ear plugs are highly recommended.

Shielded Metal Arc Welding and Carbon Arc Cutting - Air

THIRD EDITION

MAVCC

Student Workbook

BEST COPY AVAILABLE

Shielded Metal Arc Welding and Carbon Arc Cutting—Air

Third Edition

Student Workbook

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Workbook Contents

Unit 1 Assignment Sheet

1—Solve Problems Concerning SMAW Safety 1

Unit 2 Job Sheets

1—Start and Restart an Arc, Crater, and Backfill at the Edge While Running a Bead on Mild Steel Plate 3
2—Build a Pad on Mild Steel Plate in the Flat Position with an E6010 Electrode 9
3—Build a Pad on Mild Steel Plate in the Flat Position with an E7018 Electrode 15
4—Weld to Specifications a Fillet Weld Lap Joint in the Flat Position with an E6010 Electrode 21
5—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Flat Position with an E6010 Electrode 25
6—Weld to Specifications a Fillet Weld Lap Joint in the Flat Position with an E7018 Electrode 29
7—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Flat Position with an E7018 Electrode 33
8—Weld to Specifications a Fillet Weld Lap Joint in the Flat Position with an E7024 Electrode 37
9—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Flat Position with an E7024 Electrode 41
10—Weld to Specifications a Fillet Weld Lap Joint in the Horizontal Position with an E6010 Electrode 45
11—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Horizontal Position with an E6010 Electrode 49
12—Weld to Specifications a Fillet Weld Lap Joint in the Horizontal Position with an E7018 Electrode 53
13—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Horizontal Position with an E7018 Electrode 57
14—Weld to Specifications a Fillet Weld Lap Joint in the Horizontal Position with an E7024 Electrode 61
15—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Horizontal Position with an E7024 Electrode 65
16—Weld to Specifications a Fillet Weld Lap Joint in the Vertical Position with an E6010 Electrode 69
17—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Vertical Position with an E6010 Electrode 73
18—Weld to Specifications a Fillet Weld Lap Joint in the Vertical Position with an E7018 Electrode 77
19—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Vertical Position with an E7018 Electrode 81
20—Weld to Specifications a Fillet Weld Lap Joint in the Overhead Position with an E6010 Electrode 85
21—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Overhead Position with an E6010 Electrode 89

Workbook Contents

22—Weld to Specifications a Fillet Weld Lap Joint in the Overhead Position with an E7018 Electrode 93
23—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Overhead Position with an E7018 Electrode 97
24—Weld to Specifications a V-Groove Butt Joint in the Flat Position with an E6010 Electrode 101
25—Bend Test a Welded V-Groove Joint 107
26—Weld to Specifications a V-Groove Butt Joint in the Horizontal Position with an E6010 Electrode 111
27—Weld to Specifications a V-Groove Butt Joint ..... in the Vertical Position with an E6010 Electrode 117
28—Weld to Specifications a V-Groove Butt Joint in the Overhead Position with an E6010 Electrode 123
29—Weld to Specifications a V-Groove Butt Joint in the Flat Position with an E6010 Electrode Root and an E7018 Electrode Fill and Cap 129
30—Weld to Specifications a V-Groove Butt Joint in the Horizontal Position with an E6010 Electrode Root and an E7018 Electrode Fill and Cap 135
31—Weld to Specifications a V-Groove Butt Joint in the Vertical Position with an E6010 Electrode Root and an E7018 Electrode Fill and Cap 141
32—Weld to Specifications a V-Groove Butt Joint in the Overhead Position with an E6010 Electrode Root and an E7018 Electrode Fill and Cap 147

Unit 3 Job Sheets

1—Build a Pad on Mild Steel With a Hardfacing Electrode 153
2—Prepare and Hardface Simulated Bucket Teeth 157

Unit 4 Job Sheets

1—Gouge a Piece of Mild Steel With the Carbon Arc Arc Cutting—Air Process 163
2—Backgouge a Piece of Mild Steel Beveled Plate With the Carbon Arc Cutting—Air Process 167

Objective 16

Assignment Sheet 1—Solve Problems Concerning SMAW Safety

Name _____ Overall Rating _____

Date _____

Evaluation Criteria	Rating
• Problems were recognized	_____
• Solutions are accurate	_____

Basic Skills

Reading

Writing

Critical Thinking

Employability

Directions

Read the following statements carefully. Answer "Yes" or "No" to the question, "Is there a problem?" then, write a brief statement recommending a specific solution if a safety violation is presented.

1. A fellow student is attempting to replace a tension spring in an electrode clamp while the welding machine is turned on. Is there a problem? ____

   Solution: _____

   _____

2. A fellow student is attempting to clean a welding cable with an oily rag. Is there a problem? _____

   Solution: _____

   _____

3. A fellow student is arc welding in an unshielded area that has several other students nearby. Is there a problem? _____

   Solution: _____

   _____

4. A fellow student complains that she can't see to arc weld at 50 amps through a #8 lens shade, so she puts a #4 lens shade in her welding hood and starts to weld. Is there a problem? _____

   Solution: _____

   _____

5. A fellow student wearing a welding helmet is arc welding in such a position that there is danger that spatter and sparks will strike the left side of his face, which is uncovered. Is there a problem? _____

   Solution: _____

   _____

6. A fellow student is grinding a sample weld and is wearing safety glasses Is there a problem? _____

   Solution: _____

   _____

Objective 43

Job Sheet 1—Start and Restart an Arc, Crater, and Backfill at the Edge While Running a Bead on Mild Steel Plate

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• Start/restart technique	_____
• Crater/backfill technique	_____
• Weld quality	_____

Basic Skills

Reading

Oral Communication

Critical Thinking

Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- SMAW machine with accessories
- SMAW electrode(s) as selected by instructor
- Mild steel plate as selected by instructor
- Personal safety clothing and equipment
- Pliers
- Chipping hammer and wire brush
- Welding helmet and safety glasses

Procedure

❑ 1. Inspect the work area to make sure it is free of flammable materials and well ventilated.

❑ 2. Note the location of the nearest fire extinguisher.

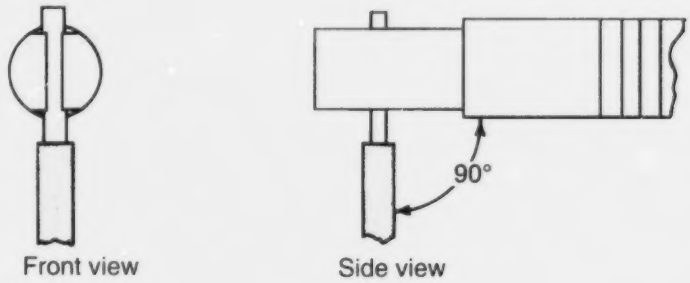
❑ 3. Attach the ground clamp to the worktable or workpiece.

❑ 4. Turn on SMAW machine.

❑ 5. Set machine to recommended amp setting and polarity, if needed.

❑ 6. Place electrode in holder as indicated.

Figure 1



❑ 7. Place the mild steel plate on a worktable directly in front of you.

❑ 8. Move the electrode down close to the metal, being careful not to start an arc, then lower your welding hood to a safe operating position.

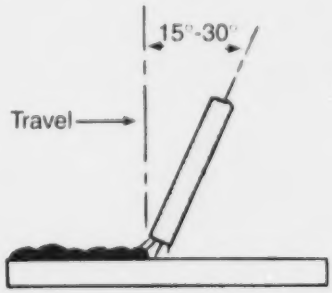
❑ 9. Start an arc with the scratch or tap method.

❑ 10. Withdraw the electrode just as the arc starts, form a long arc, then lower the electrode to a normal arc length that is slightly less than the diameter of the electrode you're using.

❑ 11. Make the bead while holding the electrode perpendicular to the plate at an angle of 15° to 30° in the direction of travel.

Note: If right-handed, weld from left to right, and if left-handed, weld from right to left.

Figure 2



❑ 12. Weld a bead about half the length of the plate, then purposely stop the weld with the following procedure:

❑ a. Stop the forward motion of the electrode.

❑ b. Gradually withdraw the electrode to break the arc and leave the crater.

❑ 13. Chip the slag off the end of the weld about 1/2″ back.

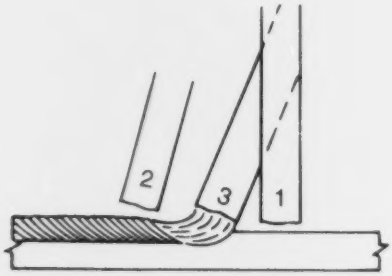
Caution: Always wear safety glasses when working with a chipping hammer.

❑ 14. Restart the arc with the following procedure:

❑ a. Restart the arc about 1/2″ in front of the forward end of the crater.

❑ b. Move the electrode quickly to the back crown of the crater and immediately resume welding in the direction of travel.

Figure 3

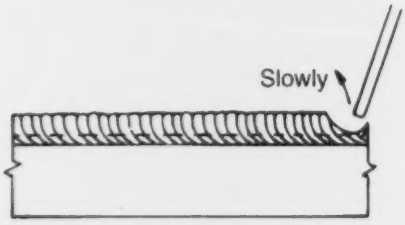


Courtesy of Lincoln Electric Company.

❑ 15. Continue welding until the bead reaches the end of the plate, then crater and backfill with the following procedure.

❑ 16. Make sure the motion is slow enough to allow the crater to fill and that the backward motion is far enough that the crater remains on top of the bead about 1/4″ to 1/2″ back from the end of the weld, then break arc quickly.

Figure 4

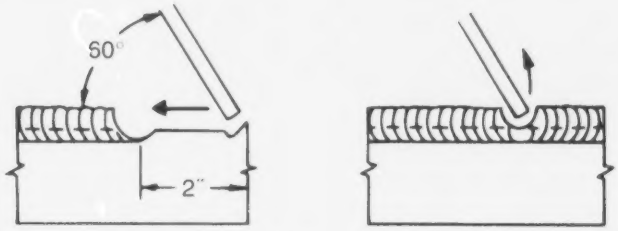


Courtesy of Lincoln Electric Company.

- ❑ 17. Take electrode from holder and place holder on hook.
- ❑ 18. Secure workpiece with pliers and clean the weld thoroughly with a chipping hammer and wire brush.
- ❑ 19. Inspect weld for bead width, undercut, spatter, poor fusion, and other irregularities.
- ❑ 20. Inspect restart point.
- ❑ 21. Inspect crater and backfill at the edge of the weld.
- ❑ 22. Have your instructor check your work.
- ❑ 23. Take the electrode holder and reinsert the electrode or start with a new electrode.
- ❑ 24. Start an arc and run another bead.
- ❑ 25. Stop the forward motion of the electrode midpoint in the bead, allow the crater to fill, and gradually withdraw the electrode to break the arc.
- ❑ 26. Chip slag off crater, restart arc, and continue welding as previously outlined.
- ❑ 27. Continue welding toward the end of the plate, but this time, break the arc about 1″ to 2″ from the end of the plate.
- ❑ 28. Crater and backfill with the following procedure:
  - ❑ a. Chip and remove slag from the end of bead.
  - ❑ b. Move to the end of the plate, restart the arc, and weld back toward the bead.
  - ❑ c. Incline the electrode about 60° in the direction of travel.

❑ d. Weld back over the crater and stop the arc by pulling up and slightly backward as the two beads run together and the crater is properly formed on top of the bead.

Figure 5



Courtesy of Lincoln Electric Company.

❑ 29. Take electrode from holder and place holder on hook.

❑ 30. Secure workpiece with pliers and clean weld thoroughly with a chipping hammer and wire brush.

❑ 31. Inspect weld for bead width, undercut, spatter, poor fusion, and other irregularities.

❑ 32. Inspect restart point.

❑ 33. Inspect crater and backfill at edge of the weld.

❑ 34. Have your instructor check your work.

❑ 35. Compare the two beads you have just welded and pay special attention to the restart points and the crater and backfill techniques used to end the beads.

❑ 36. Discuss with your instructor the crater and backfill technique you felt most comfortable with.

❑ 37. Turn off machine.

❑ 38. Repeat procedure for practice as directed by your instructor.

❑ 39. Clean area and check in tools and materials or prepare for next job sheet, as directed by your instructor.

Evaluator's Comments: _____

_____

_____

Objective 44

Job Sheet 2—Build a Pad on Mild Steel Plate in the Flat Position with an E6010 Electrode

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• First bead quality	_____
• Second bead quality	_____
• Third bead quality	_____

Basic Skills

Reading

Critical Thinking

Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

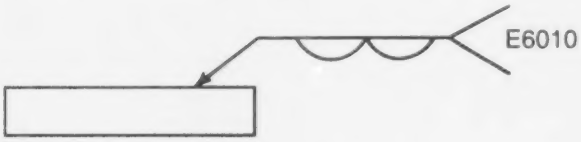
Tools, Equipment, and Materials

- SMAW machine with accessories
- Personal safety clothing and equipment
- Pliers
- Chipping hammer and wire brush
- Mild steel plates as selected by instructor
- Welding helmet and safety glasses

Specifications

1. Plate and weld symbol:

   Figure 1



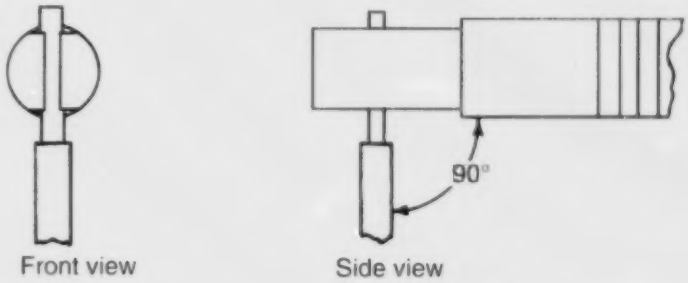
2. Filler metal: E6010, 1/8", 3/32" or 5/32"
3. Electrical characteristics: DC+
4. Position: Flat
5. Direction of welding: N/A
6. Cleaning: Chip and wire brush after each bead
7. Testing: Visual

8. Technique: Whipping

Procedure

❑ 1. Place the electrode in the holder as indicated.

Figure 2



❑ 2. Place metal on worktable directly in front of you and attach ground clamp.

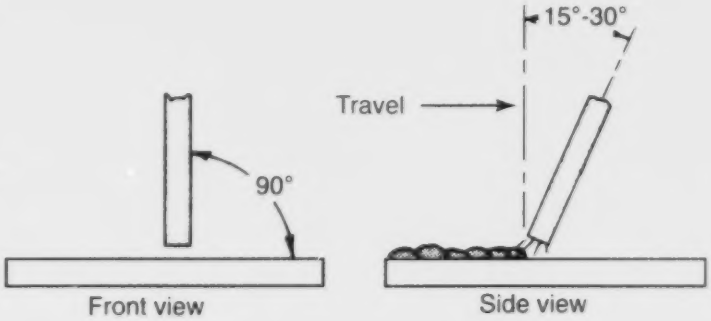
❑ 3. Move electrode down close to the base metal, being careful not to strike an arc, then lower your welding hood to a safe operating position.

❑ 4. Start an arc by moving the electrode across the base metal at an angle about the same as used in striking a match.

❑ 5. Withdraw the electrode just as the arc is struck to form a long arc, and then lower the electrode to arc length slightly less than the diameter of your electrode.

❑ 6. Make the bead while holding the electrode perpendicular to the plate at an angle of 15° to 30° in the direction of travel while using a whipping technique.

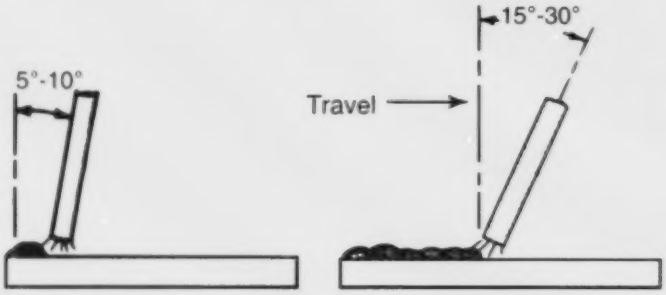
Figure 3



❑ 7. Crater and backfill at the edge of the plate.

- ❑ 8. Take electrode from holder and place holder on hook.
- ❑ 9. Secure workpiece with pliers and clean the weld thoroughly with the chipping hammer and wire brush.
- ❑ 10. Inspect weld for bead width, undercut, spatter, poor fusion, and other defects.
- ❑ 11. Have your instructor check your work.
- ❑ 12. Reinsert electrode in holder and position yourself properly over the workpiece.
- ❑ 13. Start the second bead at the toe of the first bead so that the toe of the second bead laps to the center of the first bead, or at the highest point of the break and the electrode is 5° to 10° short of perpendicular.

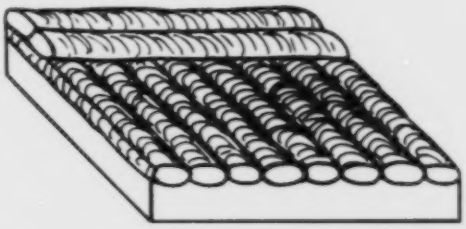
Figure 4



- ❑ 14. Continue using the whipping technique to complete second bead so that it is the same length as the first bead, then stop, clean, and inspect.
- ❑ 15. Continue making beads as required to cover the plate by starting at the toe of each preceding bead and keeping the electrode adjusted 5° to 10° short of perpendicular.
- ❑ 16. Clean each bead thoroughly and inspect for defects.
- ❑ 17. Complete first layer of beads and inspect the pad.

❑ 18. Turn the workpiece at a 90° angle and weld the first bead of the second layer using the same whipping technique as used on the first layer.

Figure 5



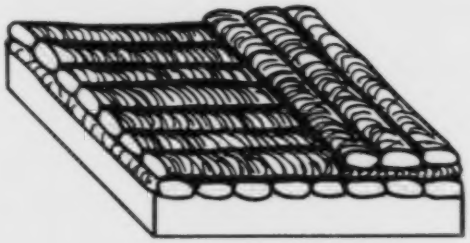
❑ 19. Clean and inspect first bead on the second layer, then continue with all beads on the second layer, being sure to adjust electrode angle and continue using the whipping technique with each bead.

❑ 20. Clean and inspect each bead.

❑ 21. Have your instructor check your completed second layer.

❑ 22. Turn the workpiece at a 90° angle and weld the first bead of the third layer the same as the first beads on layers one and two.

Figure 6



❑ 23. Clean and inspect the first bead of the third layer, then continue making beads to complete the third layer on the pad.

❑ 24. Adjust electrode angle as required and continue to use the whipping technique.

❑ 25. Complete, clean, and inspect third layer and have your instructor check your work.

❑ 26. Continue adding layers to the pad as directed by your instructor.

- ❑ 27. Stop after each layer and have your instructor check your work.
- ❑ 28. Shut down equipment, clean up area, and check in tools and materials, or prepare for next job sheet as directed by your instructor.

Evaluator's Comments: _____

_____

_____

Objective 45

Job Sheet 3—Build a Pad on Mild Steel Plate in the Flat Position with an E7018 Electrode

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• First bead quality	_____
• Second bead quality	_____
• Third bead quality	_____

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

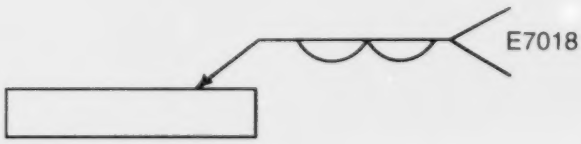
Tools, Equipment, and Materials

- SMAW machine with accessories
- Personal safety clothing and equipment
- Pliers
- Chipping hammer and wire brush
- Mild steel plates as selected by instructor
- Welding helmet and safety glasses

Specifications

1. Plate and weld symbol:

   Figure 1



2. Filler metal: E7018, 1/8", 3/32" or 5/32"
3. Electrical characteristics: DC+ or AC
4. Position: Flat
5. Direction of welding: N/A
6. Cleaning: Chip and wire brush after each bead

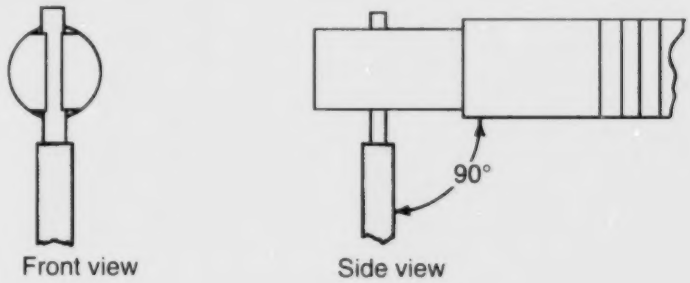
7. Testing: Visual

8. Technique: Drag

Procedure

❑ 1. Place the electrode in the holder as indicated.

Figure 2



❑ 2. Place metal on worktable directly in front of you and attach ground clamp.

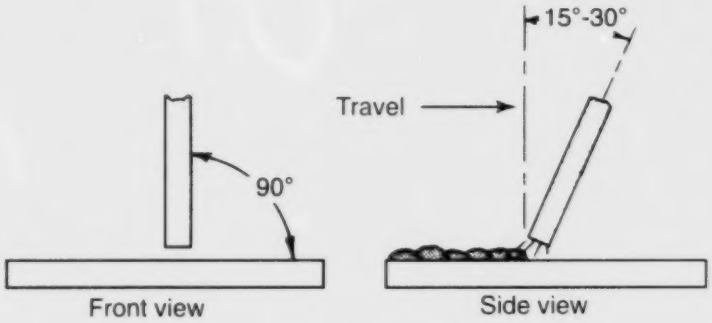
❑ 3. Move electrode down close to the base metal, being careful not to strike an arc, then lower your welding hood to a safe operating position.

❑ 4. Start an arc by moving the electrode across the base metal at an angle about the same as used in striking a match.

❑ 5. Withdraw the electrode just as the arc is struck to form a long arc, and then lower the electrode to minimal arc length.

❑ 6. Make the bead while holding the electrode perpendicular to the plate at an angle of 15° to 30° in the direction of travel while using a drag technique.

Figure 3



❑ 7. Crater and backfill at the edge of the plate.

❑ 8. Take electrode from holder and place holder on hook.

❑ 9. Secure workpiece with pliers and clean the weld thoroughly with the chipping hammer and wire brush.

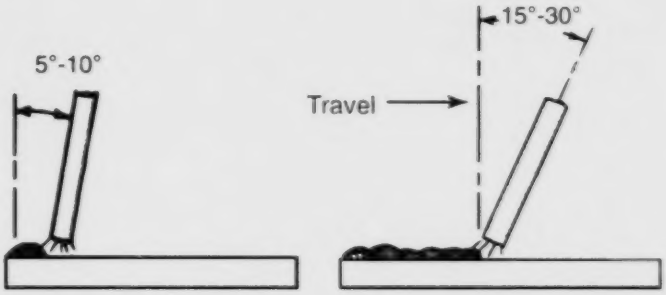
❑ 10. Inspect weld for bead width, undercut, spatter, poor fusion, and other defects.

❑ 11. Have your instructor check your work.

❑ 12 Reinsert electrode in holder and position yourself properly over the workpiece.

❑ 13. Start the second bead at the toe of the first bead so that the toe of the second bead laps to the center of the first bead, or at the highest point of the first bead and the electrode is 5° to 10° short of perpendicular.

Figure 4



❑ 14. Continue using the drag technique to complete second bead so that it is the same length as the first bead, then stop, clean, and inspect.

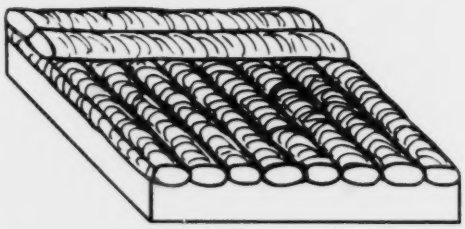
❑ 15. Continue making beads as required to cover the plate by starting at the toe of each preceding bead and keeping the electrode adjusted 5° to 10° short of perpendicular.

❑ 16. Clean each bead thoroughly and inspect for defects.

❑ 17. Complete first layer of beads and inspect the pad.

❑ 18. Turn the workpiece at a 90° angle and weld the first bead of the second layer using the same drag technique as used on the first layer.

Figure 5



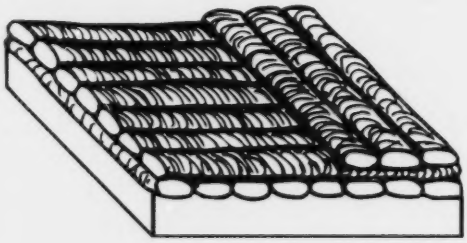
❑ 19. Clean and inspect first bead on the second layer, then continue with all beads on the second layer, being sure to adjust electrode angle and continue using the drag technique with each bead.

❑ 20. Clean and inspect each bead.

❑ 21. Have your instructor check your completed second layer.

❑ 22. Turn the workpiece at a 90° angle and weld the first bead of the third layer the same as the first beads on layers one and two.

Figure 6



❑ 23. Clean and inspect the first bead of the third layer, then continue making beads to complete the third layer on the pad.

❑ 24. Adjust electrode angle as required and continue to use the drag technique.

❑ 25. Complete, clean, and inspect third layer and have your instructor check your work.

❑ 26. Continue adding layers to the pad as directed by your instructor.

❑ 27. Stop after each layer and have your instructor check your work.

❑ 28. Shut down equipment, clean up area, and check in tools and materials, or prepare for next job sheet as directed by your instructor.

Evaluator's Comments: _____

_____

_____

Objective 46

Job Sheet 4—Weld to Specifications a Fillet Weld Lap Joint in the Flat Position with an E6010 Electrode

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• First bead quality	_____
• Second bead quality	_____
• Third bead quality	_____

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

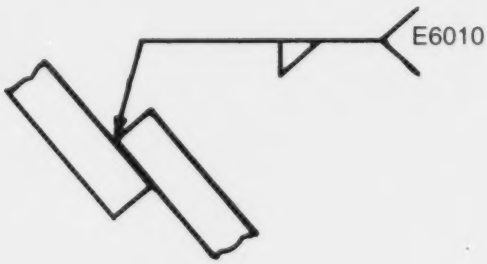
Tools, Equipment, and Materials

- SMAW machine with accessories
- Personal safety clothing and equipment
- Pliers
- Chipping hammer and wire brush
- Fitter's hammer
- Bench vise
- Mild steel plate as selected by instructor
- Welding helmet and safety glasses

Specifications

1. Joint design and weld symbol:

   Figure 1



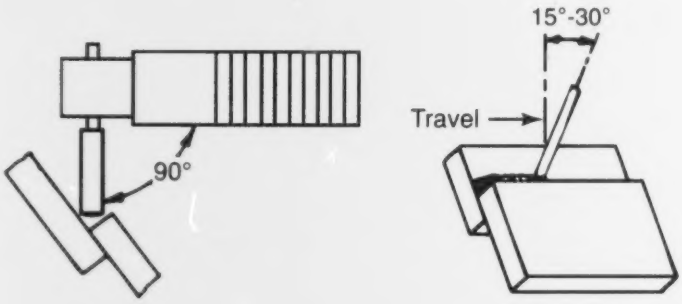
2. Filler metal and number of beads: E6010, 1/8", 3/32" or 5/32", single pass
3. Electrical characteristics: DC+
4. Position: 1F

5. Direction of welding: N/A
6. Cleaning: Chip and wire brush
7. Testing: Visual and break test
8. Technique: Whipping

Procedure

- ❑ 1. Attach ground clamp to table or workpiece.
- ❑ 2. Select correct polarity for electrode.
- ❑ 3. Turn on welding machine.
- ❑ 4. Adjust to correct amperage by running short beads on scrap material.
- ❑ 5. Prepare plates as required to form the joint and tack weld both ends of the joint.
- ❑ 6. Place the joint so the weld will be in the correct position.
- ❑ 7. Place electrode in holder as indicated.

Figure 2



- ❑ 8. Start arc and adjust electrode to correct arc length.
- ❑ 9. Adjust travel speed and electrode angle as required to make correct bead shape.
- ❑ 10. Weld the entire length of the joint; crater and backfill at the edge of the joint.
- ❑ 11. Secure the workpiece with pliers, and chip and brush the weld.
- ❑ 12. Inspect weld visually for undercutting, too much spatter, and bead shape.

- ❑ 13. Have your instructor check your work.
- ❑ 14. Break test the plates by placing one plate securely in a vise and hammering on the back side of the other plate.

  Note: Follow your instructor's directions for breaking the weld.
- ❑ 15. Inspect the bead to see if it broke down the middle as it should, and inspect for even penetration on both plates.
- ❑ 16. Tack weld the plates back together if required by your instructor.

  Note: The three following items are optional, depending on instructor's directions.
- ❑ 17. Adjust machine, electrode angle, and travel speed as required and weld other side of joint.
- ❑ 18. Secure workpiece with pliers, and chip and brush.
- ❑ 19. Inspect and test weld.
- ❑ 20. Have your instructor check your work.
- ❑ 21. Turn off machine.
- ❑ 22. Check in tools and materials and clean area, or prepare for next job sheet as directed by your instructor.

Evaluator's Comments: _____

_____

_____

Objective 47

Job Sheet 5—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Flat Position with an E6010 Electrode

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• First bead quality	_____
• Quality of other passes	_____

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

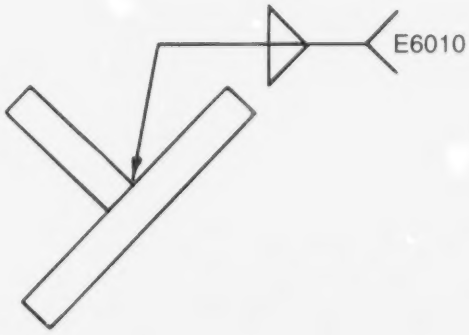
Tools, Equipment, and Materials

- SMAW machine with accessories
- Personal safety clothing and equipment
- Pliers
- Chipping hammer and wire brush
- Mild steel plates as selected by instructor
- Welding helmet and safety glasses

Specifications

1. Joint design and weld symbol:

Figure 1



2. Filler metal and number of beads: E6010, 1/8", 3/32" or 5/32", three or more passes
3. Electrical characteristics: DC+
4. Position: 1F
5. Direction of welding: N/A
6. Cleaning: Chip and wire brush
7. Testing: Visual
8. Technique: Whipping

Procedure

❑ 1. Attach ground clamp to table or workpiece.

❑ 2. Select correct polarity for electrode.

❑ 3. Turn on welding machine.

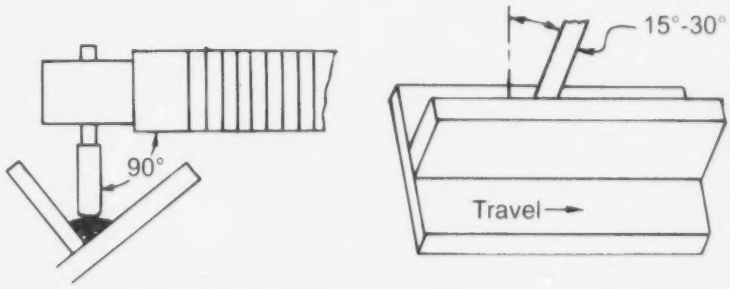
❑ 4. Adjust to correct amperage by running short beads on scrap material.

❑ 5. Prepare plates as required to form the joint and tack weld both ends of the joint.

❑ 6. Place the joint so the weld will be in the correct position.

❑ 7. Place electrode in holder as indicated.

Figure 2



❑ 8. Start an arc and adjust electrode to correct arc length.

❑ 9. Adjust travel speed and electrode angle as required to make correct bead shape.

❑ 10. Weld the entire length of the joint; crater and backfill at the edge of the joint.

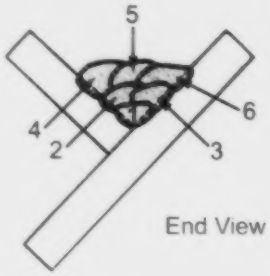
❑ 11. Secure the workpiece with pliers, and chip and brush the weld.

❑ 12. Inspect weld visually for undercutting, too much spatter, and bead shape.

❑ 13. Have your instructor check your work.

❑ 14. Weld other passes as required and be sure to clean and inspect each pass.

Figure 3



❑ 15. Have your instructor check your work.

❑ 16. Repeat procedure for other side of joint, if required by your instructor.

❑ 17. Have your instructor check your work.

❑ 18. Turn off machine.

❑ 19. Check in tools and materials and clean area, or prepare for next job sheet as directed by your instructor.

Evaluator's Comments: _____

_____

_____

Objective 48

Job Sheet 6—Weld to Specifications a Fillet Weld Lap Joint in the Flat Position with an E7018 Electrode

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• First bead quality	_____
• Quality of other passes	_____

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

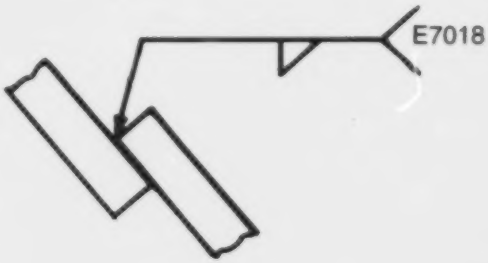
Tools, Equipment, and Materials

- SMAW machine with accessories
- Personal safety clothing and equipment
- Pliers
- Bench vise
- Fitter's hammer
- Chipping hammer and wire brush
- Mild steel plates as selected by instructor
- Welding helmet and safety glasses

Specifications

1. Joint design and weld symbol:

Figure 1



2. Filler metal and number of beads: E7018, 1/8", 3/32" or 5/32", single pass
3. Electrical characteristics: DC+
4. Position: 1F
5. Direction of welding: N/A
6. Cleaning: Chip and wire brush
7. Testing: Visual and break test
8. Technique: Drag

Procedure

- ❑ 1. Attach ground clamp to table or workpiece.
- ❑ 2. Select correct polarity for electrode.
- ❑ 3. Turn on welding machine.
- ❑ 4. Adjust to correct amperage by running short beads on scrap material.
- ❑ 5. Prepare plates as required to form the joint and tack weld both ends of the joint.
- ❑ 6. Place the joint so the weld will be in the correct position.
- ❑ 7. Place electrode in holder as indicated.

Figure 2

- ❑ 8. Start an arc and adjust electrode to correct arc length.
- ❑ 9. Adjust travel speed and electrode angle as required to make correct bead shape.

234

- ❑ 10. Weld the entire length of the joint; crater and backfill at the edge of the joint.
- ❑ 11. Secure the workpiece with pliers, and chip and brush the weld.
- ❑ 12. Inspect weld visually for undercutting, too much spatter, and bead shape.
- ❑ 13. Have your instructor check your work.
- ❑ 14. Break test the plates by placing one plate securely in a vise and hammering on the back side of the other plate.

  Note: Follow your instructor's directions for breaking the weld.
- ❑ 15. Inspect the bead to see if it broke down the middle as it should, and inspect for even penetration on both plates.
- ❑ 16. Tack weld the plates back together, if required by your instructor.

  Note: The three following items are optional, depending on instructor's directions.
- ❑ 17. Adjust machine, electrode angle, and travel speed as required and weld other side of joint.
- ❑ 18. Secure workpiece with pliers, and chip and brush.
- ❑ 19. Inspect and test weld.
- ❑ 20. Have your instructor check your work.
- ❑ 21. Turn off machine.
- ❑ 22. Check in tools and materials and clean area, or prepare for next job sheet as directed by your instructor.

Evaluator's Comments: _____

_____

_____

Objective 49

Job Sheet 7—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Flat Position with an E7018 Electrode

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• First bead quality	_____
• Quality of other passes	_____

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

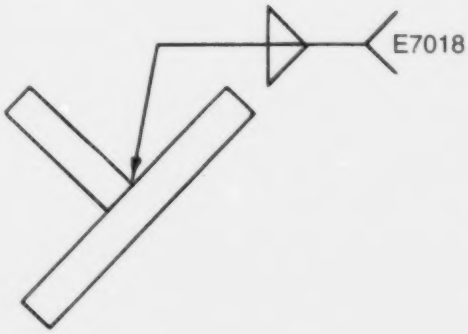
Tools, Equipment, and Materials

- SMAW machine with accessories
- Personal safety clothing and equipment
- Pliers
- Chipping hammer and wire brush
- Mild steel plates as selected by instructor
- Welding helmet and safety glasses

Specifications

1. Joint design and weld symbol:

Figure 1

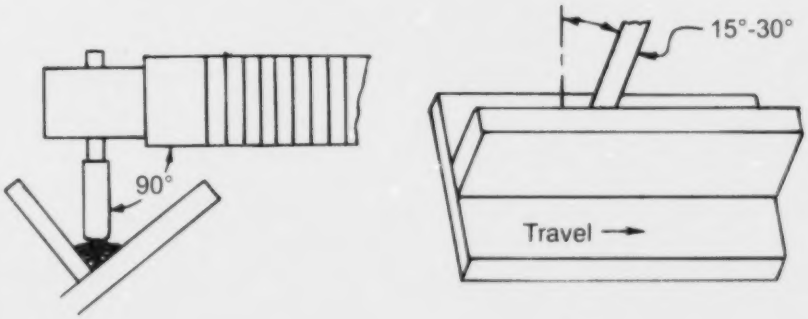


2. Filler metal and number of beads: E7018, 1/8", 3/32" or 5/32", three or more passes
3. Electrical characteristics: DC+
4. Position: 1F
5. Direction of welding: N/A
6. Cleaning: Chip and wire brush
7. Testing: Visual
8. Technique: Drag

Procedure

- ❑ 1. Attach ground clamp to table or workpiece.
- ❑ 2. Select correct polarity for electrode.
- ❑ 3. Turn on welding machine.
- ❑ 4. Adjust to correct amperage by running short beads on scrap material.
- ❑ 5. Prepare plates as required to form the joint and tack weld both ends of the joint.
- ❑ 6. Place the joint so the weld will be in the correct position.
- ❑ 7. Place electrode in holder as indicated.

Figure 2

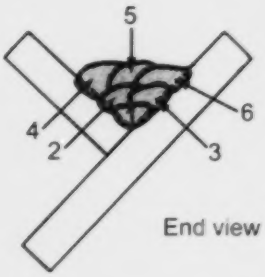


- ❑ 8. Start an arc and adjust electrode to correct arc length.
- ❑ 9. Adjust travel speed and electrode angle as required to make correct bead shape.

237

- ❑ 10. Weld the entire length of the joint; crater and backfill at the edge of the joint.
- ❑ 11. Secure the workpiece with pliers, and chip and brush the weld.
- ❑ 12. Inspect weld visually for undercutting, too much spatter, and bead shape.
- ❑ 13. Have your instructor check your work.
- ❑ 14. Weld other passes as required and be sure to clean and inspect each pass.

Figure 3



- ❑ 15. Have your instructor check your work.
- ❑ 16. Repeat procedure for other side of joint, if required by your instructor.
- ❑ 17. Clean and inspect all passes.
- ❑ 18. Have your instructor check your work.
- ❑ 19. Turn off machine.
- ❑ 20. Check in tools and materials and clean area, or prepare for next job sheet as directed by your instructor.

Evaluator's Comments: _____

_____

_____

Objective 50

Job Sheet 8—Weld to Specifications a Fillet Weld Lap Joint in the Flat Position with an E7024 Electrode

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• First bead quality	_____
• Bead quality after break	_____
• Quality of other passes	_____

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

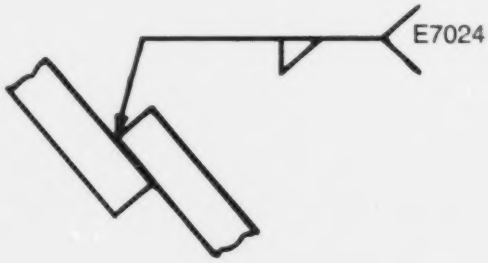
Tools, Equipment, and Materials

- SMAW machine with accessories
- Personal safety clothing and equipment
- Pliers
- Chipping hammer and wire brush
- Bench vise and fitter's hammer
- Mild steel plates as selected by instructor
- Welding helmet and safety glasses

Specifications

1. Joint design and weld symbol:

Figure 1



2. Filler metal and number of beads: E7024, 1/8″ or 5/32″, single pass

3. Electrical characteristics: AC, DC+, or DC–
4. Position: 1F
5. Direction of welding: N/A
6. Cleaning: Chip and wire brush
7. Testing: Visual and break test
8. Technique: Drag

Procedure

❑ 1. Attach ground clamp to table or workpiece.

❑ 2. Select correct polarity for electrode.

❑ 3. Turn on welding machine.

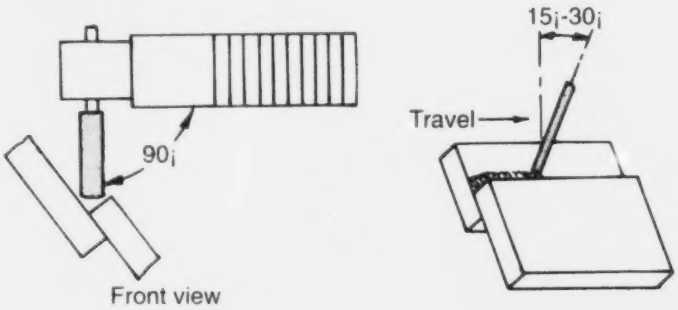
❑ 4. Adjust to correct amperage by running short beads on scrap material.

❑ 5. Prepare plates as required to form the joint and tack weld both ends of the joint.

❑ 6. Place the joint so the weld will be in the correct position.

❑ 7. Place electrode in holder as indicated.

Figure 2



❑ 8. Start an arc and adjust electrode to correct arc length.

❑ 9. Adjust travel speed and electrode angle as required to make correct bead shape.

❑ 10. Weld the entire length of the joint; crater and backfill at the edge of the joint.

- ❑ 11. Secure the workpiece with pliers, and chip and brush the weld.
- ❑ 12. Inspect weld visually for undercutting, too much spatter, and bead shape.
- ❑ 13. Have your instructor check your work.
- ❑ 14. Break test the plates by placing one plate securely in a vise and hammering on the back side of the other plate.

  Note: Follow your instructor's directions for breaking the weld.
- ❑ 15. Inspect the bead to see if it broke down the middle as it should, and inspect for even penetration on both plates.
- ❑ 16. Tack weld the plates back together, if required by your instructor.

  Note: The three following items are optional, depending on instructor's directions.
- ❑ 17. Adjust machine, electrode angle, and travel speed as required and weld other side of joint.
- ❑ 18. Secure workpiece with pliers, and chip and brush.
- ❑ 19. Inspect and test weld.
- ❑ 20. Have your instructor check your work.
- ❑ 21. Turn off machine.
- ❑ 22. Check in tools and materials and clean area, or prepare for next job sheet as directed by your instructor.

Evaluator's Comments: _____

_____

_____

Objective 51

Job Sheet 9—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Flat Position with an E7024 Electrode

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• First bead quality	_____
• Quality of other passes	_____

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

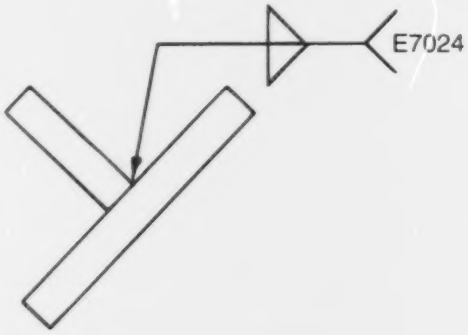
Tools, Equipment, and Materials

- SMAW machine with accessories
- Personal safety clothing and equipment
- Pliers
- Chipping hammer and wire brush
- Mild steel plates as selected by instructor
- Welding helmet and safety glasses

Specifications

1. Joint design and weld symbol:

Figure 1

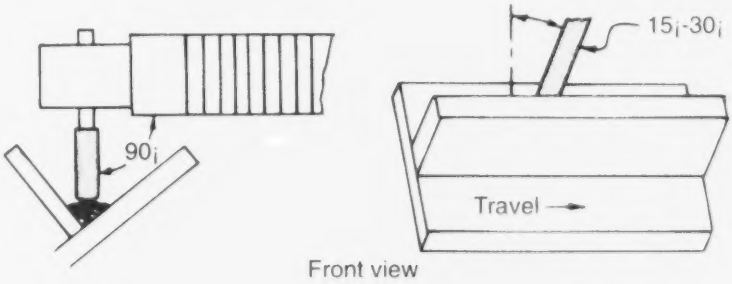


2. Filler metal and number of beads: E7024, 1/8" or 5/32", three or more passes
3. Electrical characteristics: DC+or DC–
4. Position: 1F
5. Direction of welding: N/A
6. Cleaning: Chip and wire brush
7. Testing: Visual
8. Technique: Drag

Procedure

- ❑ 1. Attach ground clamp to table or workpiece.
- ❑ 2. Select correct polarity for electrode.
- ❑ 3. Turn on welding machine.
- ❑ 4. Adjust to correct amperage by running short beads on scrap material.
- ❑ 5. Prepare plates as required to form the joint and tack weld both ends of the joint.
- ❑ 6. Place the joint so the weld will be in the correct position.
- ❑ 7. Place electrode in holder as indicated.

Figure 2

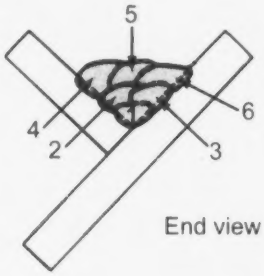


- ❑ 8. Start an arc and adjust electrode to correct arc length.
- ❑ 9. Adjust travel speed and electrode angle as required to make correct bead shape.

243

- ❑ 10. Weld the entire length of the joint; crater and backfill at the edge of the joint.
- ❑ 11. Secure the workpiece with pliers, and chip and brush the weld.
- ❑ 12. Inspect weld visually for undercutting, too much spatter, and bead shape.
- ❑ 13. Have your instructor check your work.
- ❑ 14. Weld other passes as required and be sure to clean and inspect each pass.

Figure 3



- ❑ 15. Have your instructor check your work.
- ❑ 16. Repeat procedure for other side of joint, if required by your instructor.
- ❑ 17. Clean and inspect all passes.
- ❑ 18. Have your instructor check your work.
- ❑ 19. Turn off machine.
- ❑ 20. Check in tools and materials and clean area, or prepare for next job sheet as directed by your instructor.

Evaluator's Comments: _____

_____

_____

Objective 52

Job Sheet 10—Weld to Specifications a Fillet Weld Lap Joint in the Horizontal Position with an E6010 Electrode

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• First bead quality	_____
• Quality after break test	_____
• Quality of other beads	_____

Basic Skills

Reading

Critical Thinking

Technology

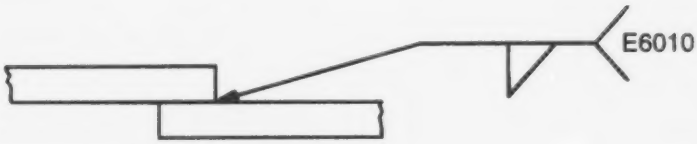
Tools, Equipment, and Materials

- SMAW machine with accessories
- Personal safety clothing and equipment
- Pliers
- Chipping hammer and wire brush
- Bench vise and fitter's hammer
- Mild steel plates as selected by instructor
- Welding helmet and safety glasses

Specifications

1. Joint design and weld symbol:

   Figure 1



2. Filler metal and number of beads: E6010, 1/8", 3/32" or 5/32", single pass
3. Electrical characteristics: DC+
4. Position: 2F
5. Direction of welding: N/A
6. Cleaning: Chip and wire brush

7. Testing: Visual and break test

8. Technique: Whipping

Procedure

❑ 1. Attach ground clamp to table or workpiece.

❑ 2. Select correct polarity for electrode.

❑ 3. Turn on welding machine.

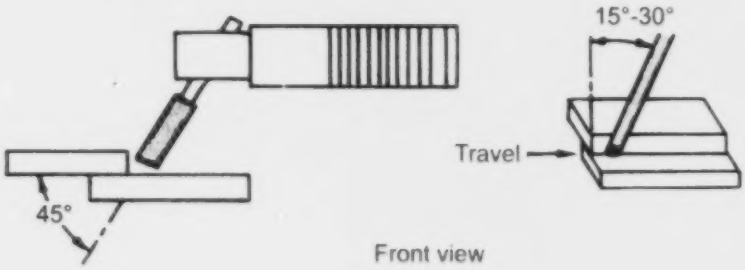
❑ 4. Adjust to correct amperage by running short beads on scrap material.

❑ 5. Prepare plates as required to form the joint and tack weld both ends of the joint.

❑ 6. Place the joint so the weld will be in the correct position.

❑ 7. Place electrode in holder as indicated.

Figure 2



❑ 8. Start an arc and adjust electrode to correct arc length.

❑ 9. Adjust travel speed and electrode angle as required to make correct bead shape.

❑ 10. Weld the entire length of the joint; crater and backfill at the edge of the joint.

❑ 11. Secure the workpiece with pliers, and chip and brush the weld.

❑ 12. Inspect weld visually for undercutting, too much spatter, and bead shape.

❑ 13. Have your instructor check your work.

246

- ❑ 14. Break test the plates by placing one plate securely in a vise and hammering on the back side of the other plate.

  Note: Follow your instructor's directions for breaking the weld.

- ❑ 15. Inspect the bead to see if it broke down the middle as it should, and inspect for even penetration on both plates.

- ❑ 16. Tack weld the plates back together, if required by your instructor.

  Note: The three following items are optional, depending on instructor's directions.

- ❑ 17. Adjust machine, electrode angle, and travel speed as required and weld other side of joint.

- ❑ 18. Secure workpiece with pliers, and chip and brush.

- ❑ 19. Inspect and test weld.

- ❑ 20. Have your instructor check your work.

- ❑ 21. Turn off machine.

- ❑ 22. Check in tools and materials and clean area, or prepare for next job sheet as directed by your instructor.

Evaluator's Comments: _____

_____

_____

Objective 53

Job Sheet 11—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Horizontal Position with an E6010 Electrode

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• First bead quality	_____
• Quality of other passes	_____

Basic Skills

Reading

Critical Thinking

Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

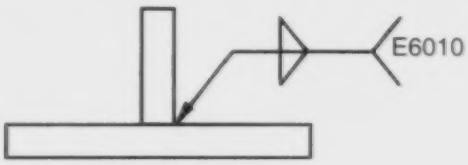
Tools, Equipment, and Materials

- SMAW machine with accessories
- Personal safety clothing and equipment
- Pliers
- Chipping hammer and wire brush
- Mild steel plates as selected by instructor
- Welding helmet and safety glasses

Specifications

1. Joint design and weld symbol:

   Figure 1



2. Filler metal and number of beads: E6010, 1/8", 3/32" or 5/32", three or more passes

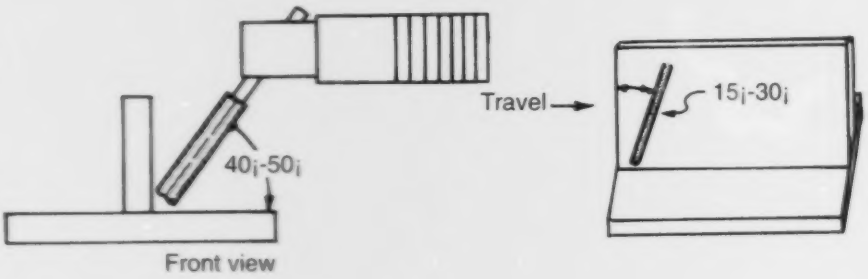
3. Electrical characteristics: DC+

4. Position: 2F
5. Direction of welding: N/A
6. Cleaning: Chip and wire brush
7. Testing: Visual
8. Technique: Whipping

Procedure

- ❑ 1. Attach ground clamp to table or workpiece.
- ❑ 2. Select correct polarity for electrode.
- ❑ 3. Turn on welding machine.
- ❑ 4. Adjust to correct amperage by running short beads on scrap material.
- ❑ 5. Prepare plates as required to form the joint and tack weld both ends of the joint.
- ❑ 6. Place the joint so the weld will be in the correct position.
- ❑ 7. Place electrode in holder as indicated.

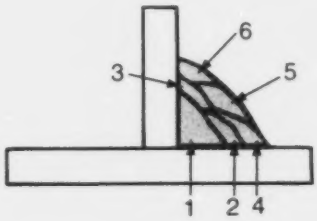
Figure 2



- ❑ 8. Start an arc and adjust electrode to correct arc length.
- ❑ 9. Adjust travel speed and electrode angle as required to make correct bead shape.
- ❑ 10. Weld the entire length of the joint, crater and backfill at the edge of the joint.
- ❑ 11. Secure the workpiece with pliers, and chip and brush the weld.

- ❑ 12. Inspect weld visually for undercutting, too much spatter, and bead shape.
- ❑ 13. Have your instructor check your work.
- ❑ 14. Weld other passes as required and be sure to clean and inspect each pass.

Figure 3



- ❑ 15. Have your instructor check your work.
- ❑ 16. Repeat procedure for other side of joint, if required by your instructor.
- ❑ 17. Clean and inspect all passes.
- ❑ 18. Have your instructor check your work.
- ❑ 19. Turn off machine.
- ❑ 20. Check in tools and materials and clean area, or prepare for next job sheet as directed by your instructor.

Evaluator's Comments: _____

_____

_____

Objective 54

Job Sheet 12—Weld to Specifications a Fillet Weld Lap Joint in the Horizontal Position with an E7018 Electrode

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• First bead quality	_____
• Quality after break test	_____
• Bead on other side	_____

Basic Skills

Reading

Critical Thinking

Technology

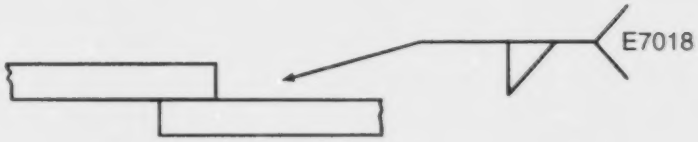
Tools, Equipment, and Materials

- SMAW machine with accessories
- Personal safety clothing and equipment
- Pliers
- Chipping hammer and wire brush
- Bench vise and fitter's hammer
- Mild steel plates as selected by instructor
- Welding helmet and safety glasses

Specifications

1. Joint design and weld symbol:

   Figure 1



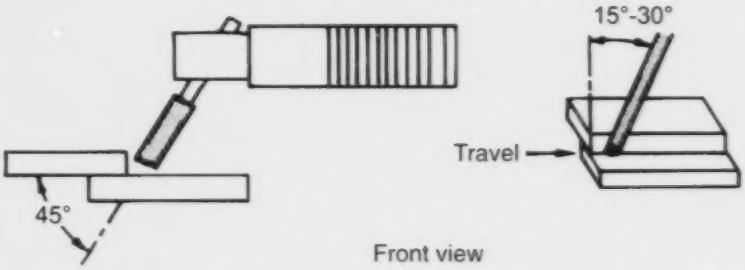
2. Filler metal and number of beads: E7018, 1/8", 3/32" or 5/32", single pass
3. Electrical characteristics: DC+ or AC
4. Position: 2F
5. Direction of welding: N/A

6. Cleaning: Chip and wire brush
7. Testing: Visual and break test
8. Technique: Drag

Procedure

- ❑ 1. Attach ground clamp to table or workpiece.
- ❑ 2. Select correct polarity for electrode.
- ❑ 3. Turn on welding machine.
- ❑ 4. Adjust to correct amperage by running short beads on scrap material.
- ❑ 5. Prepare plates as required to form the joint and tack weld both ends of the joint.
- ❑ 6. Place the joint so the weld will be in the correct position.
- ❑ 7. Place electrode in holder as indicated.

Figure 2



- ❑ 8. Start an arc and adjust electrode to correct arc length.
- ❑ 9. Adjust travel speed and electrode angle as required to make correct bead shape.
- ❑ 10. Weld the entire length of the joint; crater and backfill at the edge of the joint.
- ❑ 11. Secure the workpiece with pliers, and chip and brush the weld.
- ❑ 12. Inspect weld visually for undercutting, too much spatter, and bead shape.
- ❑ 13. Have your instructor check your work.

- ❑ 14. Break test the plates by placing one plate securely in a vise and hammering on the back side of the other plate.

  Note: Follow your instructor's directions for breaking the weld.

- ❑ 15. Inspect the bead to see if it broke down the middle as it should, and inspect for even penetration on both plates.

- ❑ 16. Tack weld the plates back together, if required by your instructor.

  Note: The three following items are optional, depending on instructor's directions.

- ❑ 17. Adjust machine, electrode angle, and travel speed as required and weld other side of joint.

- ❑ 18. Secure workpiece with pliers, and chip and brush.

- ❑ 19. Inspect and test weld.

- ❑ 20. Have your instructor check your work.

- ❑ 21. Turn off machine.

- ❑ 22. Check in tools and materials and clean area, or prepare for next job sheet as directed by your instructor.

Evaluator's Comments: _____

_____

_____

Objective 55

Job Sheet 13—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Horizontal Position with an E7018 Electrode

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• First bead quality	_____
• Quality of other beads	_____

Basic Skills

Reading Critical Thinking Technology

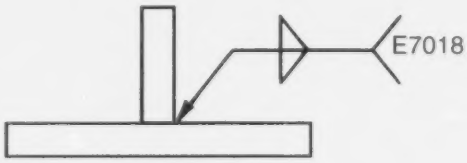
Tools, Equipment, and Materials

- SMAW machine with accessories
- Personal safety clothing and equipment
- Pliers
- Chipping hammer and wire brush
- Mild steel plates as selected by instructor
- Welding helmet and safety glasses

Specifications

1. Joint design and weld symbol:

   Figure 1



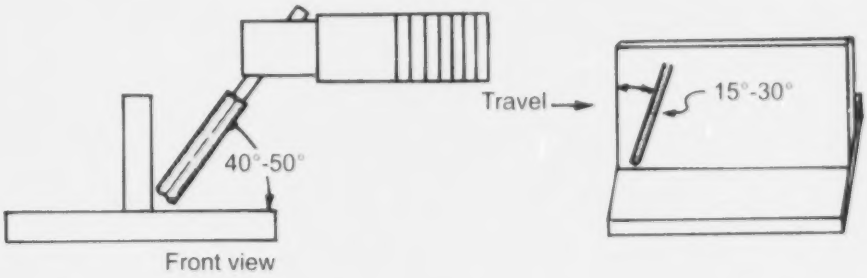
2. Filler metal and number of beads: E7018, 1/8″, 3/32″ or 5/32″, three or more passes
3. Electrical characteristics: DC+
4. Position: 2F
5. Direction of welding: N/A

6. Cleaning: Chip and wire brush
7. Testing: Visual
8. Technique: Drag

Procedure

- ❑ 1. Attach ground clamp to table or workpiece.
- ❑ 2. Select correct polarity for electrode.
- ❑ 3. Turn on welding machine.
- ❑ 4. Adjust to correct amperage by running short beads on scrap material.
- ❑ 5. Prepare plates as required to form the joint and tack weld both ends of the joint.
- ❑ 6. Place the joint so the weld will be in the correct position.
- ❑ 7. Place electrode in holder as indicated.

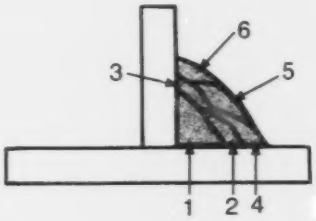
Figure 2



- ❑ 8. Start an arc and adjust electrode to correct arc length.
- ❑ 9. Adjust travel speed and electrode angle as required to make correct bead shape.
- ❑ 10. Weld the entire length of the joint; crater and backfill at the edge of the joint.
- ❑ 11. Secure the workpiece with pliers, and chip and brush the weld.
- ❑ 12. Inspect weld visually for undercutting, too much spatter, and bead shape.
- ❑ 13. Have your instructor check your work.

❑ 14. Weld other passes as required and be sure to clean and inspect each pass.

Figure 3



❑ 15. Have your instructor check your work.

❑ 16. Repeat procedure for other side of joint, if required by your instructor.

❑ 17. Clean and inspect all passes.

❑ 18. Have your instructor check your work.

❑ 19. Turn off machine.

❑ 20. Check in tools and materials and clean area, or prepare for next job sheet as directed by your instructor.

Evaluator's Comments: _____

_____

_____

Objective 56

Job Sheet 14—Weld to Specifications a Fillet Weld Lap Joint in the Horizontal Position with an E7024 Electrode

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• First bead quality	_____
• Bead quality after break test	_____
• Bead on other side	_____

Basic Skills

Reading

Critical Thinking

Technology

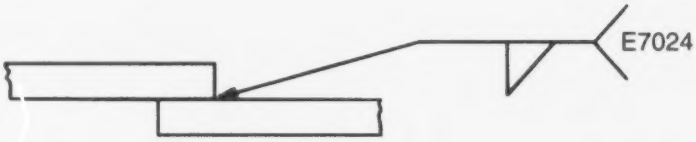
Tools, Equipment, and Materials

- SMAW machine with accessories
- Personal safety clothing and equipment
- Pliers
- Chipping hammer and wire brush
- Bench vise and fitter's hammer
- Mild steel plates as selected by instructor
- Welding helmet and safety glasses

Specifications

1. Joint design and weld symbol:

   Figure 1



2. Filler metal and number of beads: E7024, 1/8″ or 5/32″, single pass
3. Electrical characteristics: AC, DC+ or DC–
4. Position: 2F
5. Direction of welding: N/A
6. Cleaning: Chip and wire brush

7. Testing: Visual and break test

8. Technique: Drag

Procedure

❑ 1. Attach ground clamp to table or workpiece.

❑ 2. Select correct polarity for electrode.

❑ 3. Turn on welding machine.

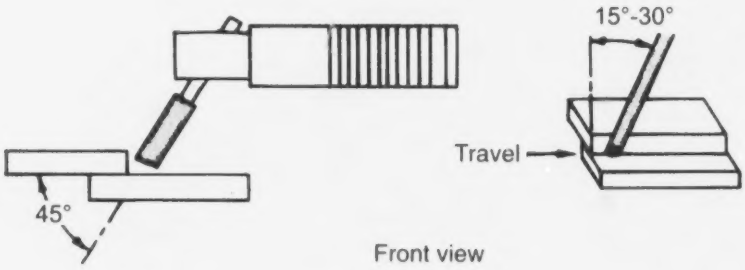
❑ 4. Adjust to correct amperage by running short beads on scrap material.

❑ 5. Prepare plates as required to form the joint and tack weld both ends of the joint.

❑ 6. Place the joint so the weld will be in the correct position.

❑ 7. Place electrode in holder as indicated.

Figure 2



❑ 8. Start an arc and adjust electrode to correct arc length.

❑ 9. Adjust travel speed and electrode angle as required to make correct bead shape.

❑ 10. Weld the entire length of the joint; crater and backfill at the edge of the joint.

❑ 11. Secure the workpiece with pliers, and chip and brush the weld.

❑ 12. Inspect weld visually for undercutting, too much spatter, and bead shape.

❑ 13. Have your instructor check your work.

- ❑ 14. Break test the plates by placing one plate securely in a vise and hammering on the back side of the other plate.

  Note: Follow your instructor's directions for breaking the weld.

- ❑ 15. Inspect the bead to see if it broke down the middle as it should, and inspect for even penetration on both plates.

- ❑ 16. Tack weld the plates back together, if required by your instructor.

  Note: The three following items are optional, depending on instructor's directions.

- ❑ 17. Adjust machine, electrode angle, and travel speed as required and weld other side of joint.

- ❑ 18. Secure workpiece with pliers, and chip and brush.

- ❑ 19. Inspect and test weld.

- ❑ 20. Have your instructor check your work.

- ❑ 21. Turn off machine.

- ❑ 22. Check in tools and materials and clean area, or prepare for next job sheet as directed by your instructor.

Evaluator's Comments: _____

_____

_____

Objective 57

Job Sheet 15—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Horizontal Position with an E7024 Electrode

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• First bead quality	_____
• Quality of other beads	_____

Basic Skills

Reading

Critical Thinking

Technology

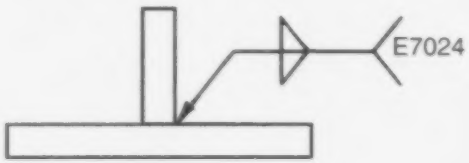
Tools, Equipment, and Materials

- SMAW machine with accessories
- Personal safety clothing and equipment
- Pliers
- Chipping hammer and wire brush
- Mild steel plates as selected by instructor
- Welding helmet and safety glasses

Specifications

1. Joint design and weld symbol:

   Figure 1



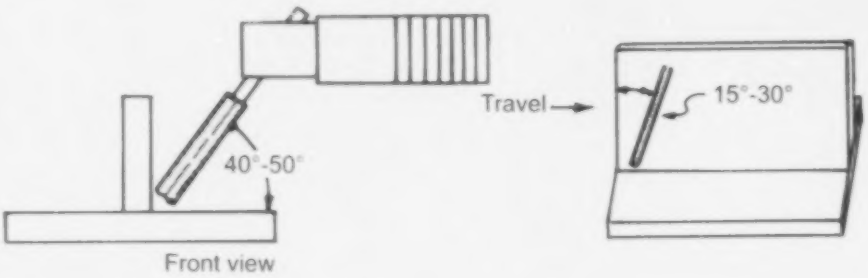
2. Filler metal and number of beads: E7024, 1/8″ or 5/32″, three or more passes
3. Electrical characteristics: AC, DC+ or DC–
4. Position: 2F
5. Direction of welding: N/A

6. Cleaning: Chip and wire brush
7. Testing: Visual
8. Technique: Drag

Procedure

- ❑ 1. Attach ground clamp to table or workpiece.
- ❑ 2. Select correct polarity for electrode.
- ❑ 3. Turn on welding machine.
- ❑ 4. Adjust to correct amperage by running short beads on scrap material.
- ❑ 5. Prepare plates as required to form the joint and tack weld both ends of the joint.
- ❑ 6. Place the joint so the weld will be in the correct position.
- ❑ 7. Place electrode in holder as indicated.

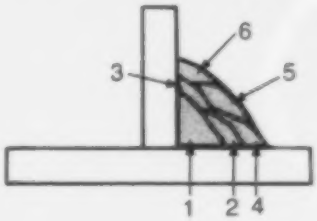
Figure 2



- ❑ 8. Start an arc and adjust electrode to correct arc length.
- ❑ 9. Adjust travel speed and electrode angle as required to make correct bead shape.
- ❑ 10. Weld the entire length of the joint; crater and backfill at the edge of the joint.
- ❑ 11. Secure the workpiece with pliers, and chip and brush the weld.
- ❑ 12. Inspect weld visually for undercutting, too much spatter, and bead shape.
- ❑ 13. Have your instructor check your work.

❑ 14. Weld other passes as required and be sure to clean and inspect each pass.

Figure 3



❑ 15. Have your instructor check your work.

❑ 16. Repeat procedure for other side of joint, if required by your instructor.

❑ 17. Clean and inspect all passes.

❑ 18. Have your instructor check your work.

❑ 19. Turn off machine.

❑ 20. Check in tools and materials and clean area, or prepare for next job sheet as directed by your instructor.

Evaluator's Comments: _____

_____

_____

Objective 58

Job Sheet 16—Weld to Specifications a Fillet Weld Lap Joint in the Vertical Position with an E6010 Electrode

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• First bead quality	_____
• Bead quality after break test	_____
• Quality of other beads	_____

Basic Skills

Reading

Critical Thinking

Technology

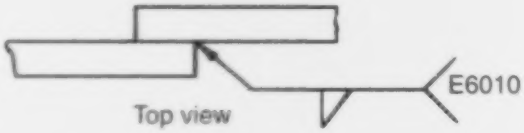
Tools, Equipment, and Materials

- SMAW machine with accessories
- Personal safety clothing and equipment
- Pliers
- Chipping hammer and wire brush
- Bench vise and fitter's hammer
- Mild steel plates as selected by instructor
- Welding helmet and safety glasses

Specifications

1. Joint design and weld symbol:

   Figure 1



2. Filler metal and number of beads: E6010, 1/8″, 3/32″ or 5/32″, single pass
3. Electrical characteristics: DC+
4. Position: 3F
5. Direction of welding: Vertical up
6. Cleaning: Chip and wire brush

7. Testing: Visual and break test

8. Technique: Whipping

Procedure

❑ 1. Attach ground clamp to table or workpiece.

❑ 2. Select correct polarity for electrode.

❑ 3. Turn on welding machine.

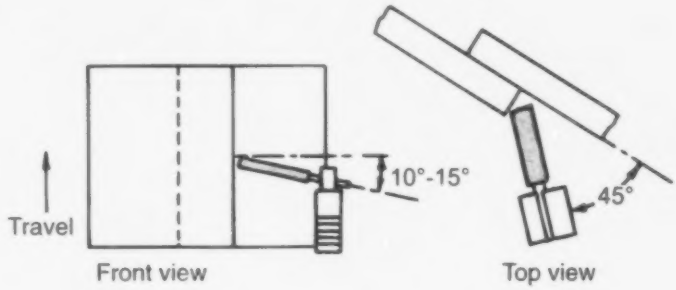
❑ 4. Adjust to correct amperage by running short beads on scrap material.

❑ 5. Prepare plates as required to form the joint and tack weld both ends of the joint.

❑ 6. Place the joint so the weld will be in the correct position.

❑ 7. Place electrode in holder as indicated.

Figure 2



❑ 8. Start an arc and adjust electrode to correct arc length.

❑ 9. Adjust travel speed and electrode angle as required to make correct bead shape.

❑ 10. Weld the entire length of the joint; crater and backfill at the edge of the joint.

❑ 11. Secure the workpiece with pliers, and chip and brush the weld.

❑ 12. Inspect weld visually for undercutting, too much spatter, and bead shape.

❑ 13. Have your instructor check your work.

264

- ❑ 14. Break test the plates by placing one plate securely in a vise and hammering on the back side of the other plate.

  Note: Follow your instructor's directions for breaking the weld.

- ❑ 15. Inspect the bead to see if it broke down the middle as it should, and inspect for even penetration on both plates.

- ❑ 16. Tack weld the plates back together, if required by your instructor.

  Note: The three following items are optional, depending on instructor's directions.

- ❑ 17. Adjust machine, electrode angle, and travel speed as required and weld other side of joint.

- ❑ 18. Secure workpiece with pliers, and chip and brush.

- ❑ 19. Inspect and test weld.

- ❑ 20. Have your instructor check your work.

- ❑ 21. Turn off machine.

- ❑ 22. Check in tools and materials and clean area, or prepare for next job sheet as directed by your instructor.

Evaluator's Comments: _____

_____

_____

Objective 59

Job Sheet 17—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Vertical Position with an E6010 Electrode

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• First bead quality	_____
• Quality of other beads	_____

Basic Skills

Reading Critical Thinking Technology

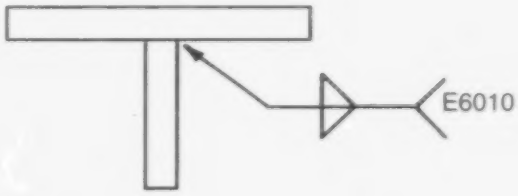
Tools, Equipment, and Materials

- SMAW machine with accessories
- Personal safety clothing and equipment
- Pliers
- Chipping hammer and wire brush
- Mild steel plates as selected by instructor
- Welding helmet and safety glasses

Specifications

1. Joint design and weld symbol:

   Figure 1



2. Filler metal and number of beads: E6010, 1/8″, 3/32″ or 5/32″, three passes
3. Electrical characteristics: DC+
4. Position: 3F

5. Direction of welding: Vertical up
6. Cleaning: Chip and wire brush
7. Testing: Visual
8. Technique: Whipping

Procedure

❑ 1. Attach ground clamp to table or workpiece.

❑ 2. Select correct polarity for electrode.

❑ 3. Turn on welding machine.

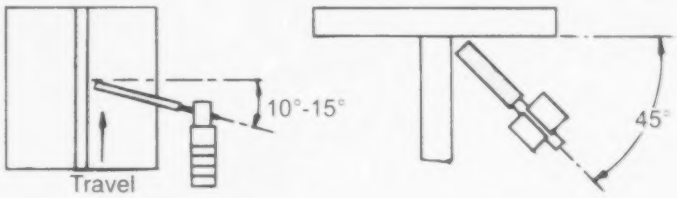
❑ 4. Adjust to correct amperage by running short beads on scrap material.

❑ 5. Prepare plates as required to form the joint and tack weld both ends of the joint.

❑ 6. Place the joint so the weld will be in the correct position.

❑ 7. Place electrode in holder as indicated.

Figure 2



Front view Top view

❑ 8. Start an arc and adjust electrode to correct arc length.

❑ 9. Adjust travel speed and electrode angle as required to make correct bead shape.

❑ 10. Weld the entire length of the joint; crater and backfill at the edge of the joint.

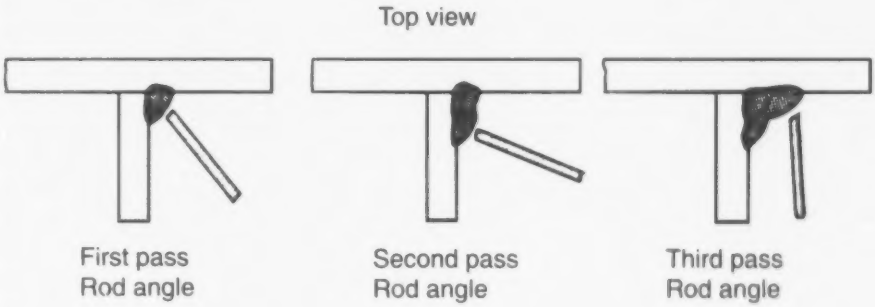
❑ 11. Secure the workpiece with pliers, and chip and brush the weld.

❑ 12. Inspect weld visually for undercutting, too much spatter, and bead shape.

❑ 13. Have your instructor check your work.

❑ 14. Weld other passes as required and be sure to clean and inspect each pass.

Figure 3



❑ 15. Have your instructor check your work.

❑ 16. Repeat procedure for other side of joint, if required by your instructor.

❑ 17. Clean and inspect all passes.

❑ 18. Have your instructor check your work.

❑ 19. Turn off machine.

❑ 20. Check in tools and materials and clean area, or prepare for next job sheet as directed by your instructor.

Evaluator's Comments: _____

_____

_____

Objective 60

Job Sheet 18—Weld to Specifications a Fillet Weld Lap Joint in the Vertical Position with an E7018 Electrode

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• First bead quality	_____
• Bead quality after break test	_____
• Quality of other beads	_____

Basic Skills

Reading

Critical Thinking

Technology

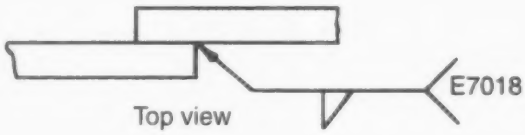
Tools, Equipment, and Materials

- SMAW machine with accessories
- Personal safety clothing and equipment
- Pliers
- Chipping hammer and wire brush
- Bench vise and fitter's hammer
- Mild steel plates as selected by instructor
- Welding helmet and safety glasses

Specifications

1. Joint design and weld symbol:

   Figure 1



2. Filler metal and number of beads: E7018, 1/8", 3/32" or 5/32", single pass
3. Electrical characteristics: DC+ or AC
4. Position: 3F
5. Direction of welding: Vertical up
6. Cleaning: Chip and wire brush

7. Testing: Visual and break test

8. Technique: Drag

Procedure

❑ 1. Attach ground clamp to table or workpiece.

❑ 2. Select correct polarity for electrode.

❑ 3. Turn on welding machine.

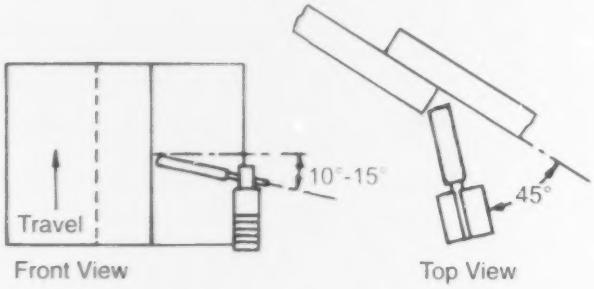
❑ 4. Adjust to correct amperage by running short beads on scrap material.

❑ 5. Prepare plates as required to form the joint and tack weld both ends of the joint.

❑ 6. Place the joint so the weld will be in the correct position.

❑ 7. Place electrode in holder as indicated.

Figure 2



❑ 8. Start an arc and adjust electrode to correct arc length.

❑ 9. Adjust travel speed and electrode angle as required to make correct bead shape.

❑ 10. Weld the entire length of the joint; crater and backfill at the edge of the joint.

❑ 11. Secure the workpiece with pliers, and chip and brush the weld.

❑ 12. Inspect weld visually for undercutting, too much spatter, and bead shape.

❑ 13. Have your instructor check your work.

- ❑ 14. Break test the plates by placing one plate securely in a vise and hammering on the back side of the other plate.

  Note: Follow your instructor's directions for breaking the weld.

- ❑ 15. Inspect the bead to see if it broke down the middle as it should, and inspect for even penetration on both plates.

- ❑ 16. Tack weld the plates back together, if required by your instructor.

  Note: The three following items are optional, depending on instructor's directions.

- ❑ 17. Adjust machine, electrode angle, and travel speed as required and weld other side of joint.

- ❑ 18. Secure workpiece with pliers, and chip and brush.

- ❑ 19. Inspect and test weld.

- ❑ 20. Have your instructor check your work.

- ❑ 21. Turn off machine.

- ❑ 22. Check in tools and materials and clean area, or prepare for next job sheet as directed by your instructor.

Evaluator's Comments: _____

_____

_____

Objective 61

Job Sheet 19—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Vertical Position with an E7018 Electrode

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• First bead quality	_____
• Quality of other beads	_____

Basic Skills

Reading

Critical Thinking

Technology

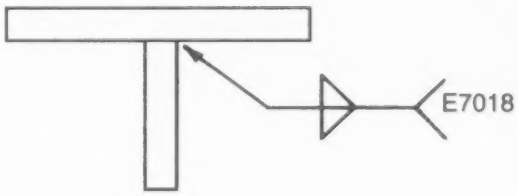
Tools, Equipment, and Materials

- SMAW machine with accessories
- Personal safety clothing and equipment
- Pliers
- Chipping hammer and wire brush
- Mild steel plates as selected by instructor
- Welding helmet and safety glasses

Specifications

1. Joint design and weld symbol:

   Figure 1



Top view

2. Filler metal and number of beads: E7018, 1/8″, 3/32″ or 5/32″, three passes

3. Electrical characteristics: DC+

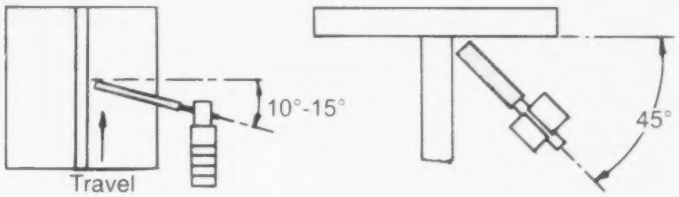
4. Position: 3F

5. Direction of welding: Vertical up
6. Cleaning: Chip and wire brush
7. Testing: Visual
8. Technique: Push, weave, or as directed

Procedure

- ❑ 1. Attach ground clamp to table or workpiece.
- ❑ 2. Select correct polarity for electrode.
- ❑ 3. Turn on welding machine.
- ❑ 4. Adjust to correct amperage by running short beads on scrap material.
- ❑ 5. Prepare plates as required to form the joint and tack weld both ends of the joint.
- ❑ 6. Place the joint so the weld will be in the correct position.
- ❑ 7. Place electrode in holder as indicated.

Figure 2

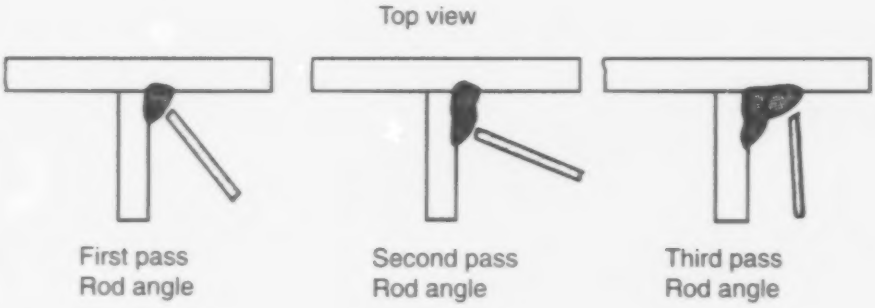


Front view Top view

- ❑ 8. Start an arc and adjust electrode to correct arc length.
- ❑ 9. Adjust travel speed and electrode angle as required to make correct bead shape.
- ❑ 10. Weld the entire length of the joint; crater and backfill at the edge of the joint.
- ❑ 11. Secure the workpiece with pliers, and chip and brush the weld.
- ❑ 12. Inspect weld visually for undercutting, too much spatter, and bead shape.
- ❑ 13. Have your instructor check your work.

❑ 14. Weld other passes as required and be sure to clean and inspect each pass.

Figure 3



❑ 15. Have your instructor check your work.

❑ 16. Repeat procedure for other side of joint, if required by your instructor.

❑ 17. Clean and inspect all passes.

❑ 18. Have your instructor check your work.

❑ 19. Turn off machine.

❑ 20. Check in tools and materials and clean area, or prepare for next job sheet as directed by your instructor.

Evaluator's Comments: _____

_____

_____

Objective 62

Job Sheet 20—Weld to Specifications a Fillet Weld Lap Joint in the Overhead Position with an E6010 Electrode

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• First bead quality	_____
• Bead quality after break test	_____
• Quality of other beads	_____

Basic Skills

Reading Critical Thinking Technology

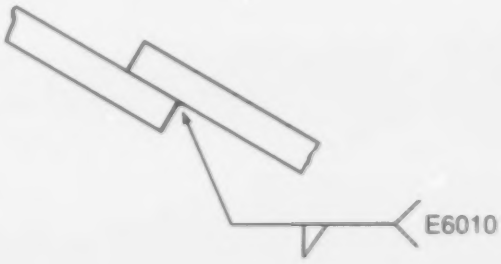
Tools, Equipment, and Materials

- SMAW machine with accessories
- Personal safety clothing and equipment
- Pliers
- Chipping hammer and wire brush
- Bench vise and fitter's hammer
- Mild steel plates as selected by instructor
- Welding helmet and safety glasses

Specifications

1. Joint design and weld symbol:

   Figure 1



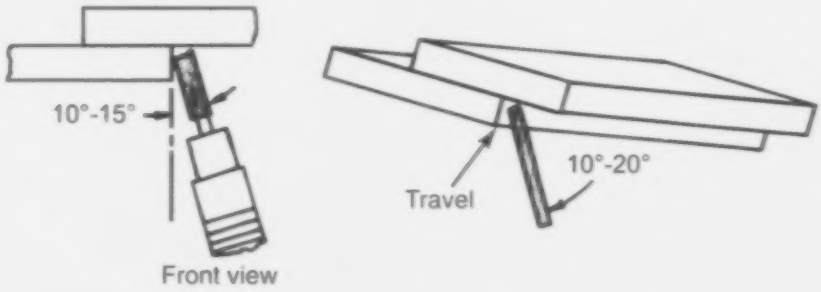
2. Filler metal and number of beads: E6010, 1/8", 3/32" or 5/32", single pass
3. Electrical characteristics: DC+
4. Position: 4F

5. Direction of welding: N/A
6. Cleaning: Chip and wire brush
7. Testing: Visual and break test
8. Technique: Whipping

Procedure

- ❑ 1. Attach ground clamp to table or workpiece.
- ❑ 2. Select correct polarity for electrode.
- ❑ 3. Turn on welding machine.
- ❑ 4. Adjust to correct amperage by running short beads on scrap material.
- ❑ 5. Prepare plates as required to form the joint and tack weld both ends of the joint.
- ❑ 6. Place the joint so the weld will be in the correct position.
- ❑ 7. Place electrode in holder as indicated.

Figure 2



- ❑ 8. Start an arc and adjust electrode to correct arc length.
- ❑ 9. Adjust travel speed and electrode angle as required to make correct bead shape.
- ❑ 10. Weld the entire length of the joint; crater and backfill at the edge of the joint.
- ❑ 11. Secure the workpiece with pliers, and chip and brush the weld.
- ❑ 12. Inspect weld visually for undercutting, too much spatter, and bead shape.

- ❑ 13. Have your instructor check your work.
- ❑ 14. Break test the plates by placing one plate securely in a vise and hammering on the back side of the other plate.

  Note: Follow your instructor's directions for breaking the weld.
- ❑ 15. Inspect the bead to see if it broke down the middle as it should, and inspect for even penetration on both plates.
- ❑ 16. Tack weld the plates back together, if required by your instructor.

  Note: The three following items are optional, depending on instructor's directions.
- ❑ 17. Adjust machine, electrode angle, and travel speed as required and weld other side of joint.
- ❑ 18. Secure workpiece with pliers, and chip and brush.
- ❑ 19. Inspect and test weld.
- ❑ 20. Have your instructor check your work.
- ❑ 21. Turn off machine.
- ❑ 22. Check in tools and materials and clean area, or prepare for next job sheet as directed by your instructor.

Evaluator's Comments: _____

_____

_____

Objective 63

Job Sheet 21—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Overhead Position with an E6010 Electrode

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• First bead quality	_____
• Quality of other beads	_____

Basic Skills

Reading

Critical Thinking

Technology

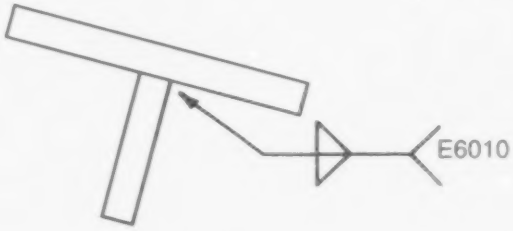
Tools, Equipment, and Materials

- SMAW machine with accessories
- Personal safety clothing and equipment
- Pliers
- Chipping hammer and wire brush
- Mild steel plates as selected by instructor
- Welding helmet and safety glasses

Specifications

1. Joint design and weld symbol:

   Figure 1



2. Filler metal and number of beads: E6010, 1/8″, 3/32″ or 5/32″, three passes

3. Electrical characteristics: DC+

4. Position: 4F

5. Direction of welding: N/A
6. Cleaning: Chip and wire brush
7. Testing: Visual
8. Technique: Whipping

Procedure

❑ 1. Attach ground clamp to table or workpiece.

❑ 2. Select correct polarity for electrode.

❑ 3. Turn on welding machine.

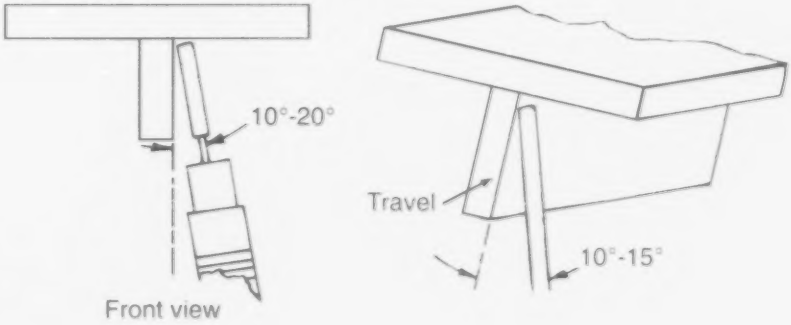
❑ 4. Adjust to correct amperage by running short beads on scrap material.

❑ 5. Prepare plates as required to form the joint and tack weld both ends of the joint.

❑ 6. Place the joint so the weld will be in the correct position.

❑ 7. Place electrode in holder as indicated.

Figure 2



❑ 8. Start an arc and adjust electrode to correct arc length.

❑ 9. Adjust travel speed and electrode angle as required to make correct bead shape.

❑ 10. Weld the entire length of the joint; crater and backfill at the edge of the joint.

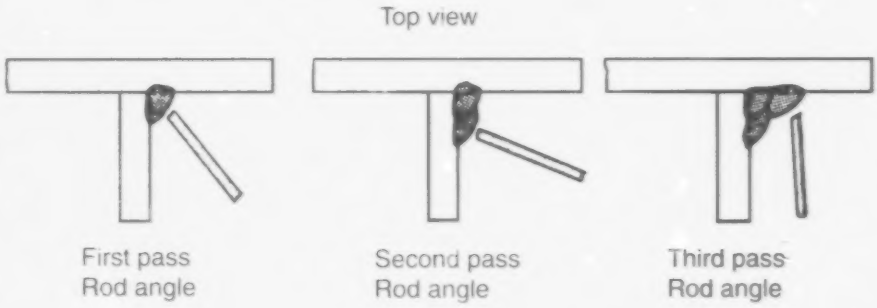
❑ 11. Secure the workpiece with pliers, and chip and brush the weld.

❑ 12. Inspect weld visually for undercutting, too much spatter, and bead shape.

❑ 13. Have your instructor check your work.

❑ 14. Weld other passes as required and be sure to clean and inspect each pass.

Figure 3



❑ 15. Have your instructor check your work.

❑ 16. Repeat procedure for other side of joint, if required by your instructor.

❑ 17. Clean and inspect all passes.

❑ 18. Have your instructor check your work.

❑ 19. Turn off machine.

❑ 20. Check in tools and materials and clean area, or prepare for next job sheet as directed by your instructor.

Evaluator's Comments: _____

_____

_____

Objective 64

Job Sheet 22—Weld to Specifications a Fillet Weld Lap Joint in the Overhead Position with an E7018 Electrode

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• First bead quality	_____
• Bead quality after break test	_____
• Quality of other beads	_____

Basic Skills

Reading

Critical Thinking

Technology

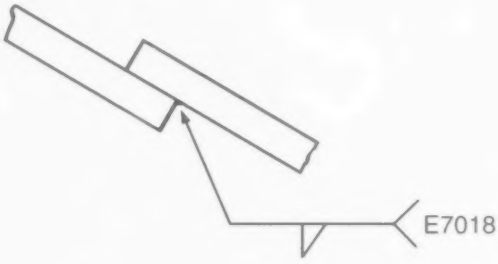
Tools, Equipment, and Materials

- SMAW machine with accessories
- Personal safety clothing and equipment
- Pliers
- Chipping hammer and wire brush
- Bench vise and fitter's hammer
- Mild steel plates as selected by instructor
- Welding helmet and safety glasses

Specifications

1. Joint design and weld symbol:

   Figure 1



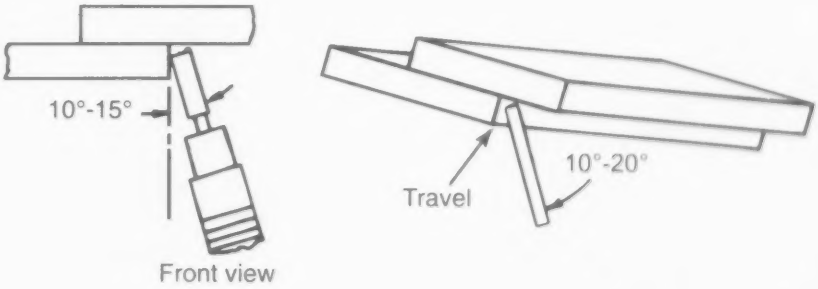
2. Filler metal and number of beads: E7018, 1/8″, 3/32″ or 5/32″, single pass
3. Electrical characteristics: DC+
4. Position: 4F

5. Direction of welding: N/A
6. Cleaning: Chip and wire brush
7. Testing: Visual and break test
8. Technique: Drag

Procedure

- ❑ 1. Attach ground clamp to table or workpiece.
- ❑ 2. Select correct polarity for electrode.
- ❑ 3. Turn on welding machine.
- ❑ 4. Adjust to correct amperage by running short beads on scrap material.
- ❑ 5. Prepare plates as required to form the joint and tack weld both ends of the joint.
- ❑ 6. Place the joint so the weld will be in the correct position.
- ❑ 7. Place electrode in holder as indicated.

Figure 2



- ❑ 8. Start an arc and adjust electrode to correct arc length.
- ❑ 9. Adjust travel speed and electrode angle as required to make correct bead shape.
- ❑ 10. Weld the entire length of the joint; crater and backfill at the edge of the joint.
- ❑ 11. Secure the workpiece with pliers, and chip and brush the weld.
- ❑ 12. Inspect weld visually for undercutting, too much spatter, and bead shape.

- ❑ 13. Have your instructor check your work.
- ❑ 14. Break test the plates by placing one plate securely in a vise and hammering on the back side of the other plate.

  Note: Follow your instructor's directions for breaking the weld.
- ❑ 15. Inspect the bead to see if it broke down the middle as it should, and inspect for even penetration on both plates.
- ❑ 16. Tack weld the plates back together, if required by your instructor.

  Note: The three following items are optional, depending on instructor's directions.
- ❑ 17. Adjust machine, electrode angle, and travel speed as required and weld other side of joint.
- ❑ 18. Secure workpiece with pliers, and chip and brush.
- ❑ 19. Inspect and test weld.
- ❑ 20. Have your instructor check your work.
- ❑ 21. Turn off machine.
- ❑ 22. Check in tools and materials and clean area, or prepare for next job sheet as directed by your instructor.

Evaluator's Comments: _____

_____

_____

Objective 65

Job Sheet 23—Weld to Specifications a Multipass Fillet Weld on a T-Joint in the Overhead Position with an E7018 Electrode

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• First bead quality	_____
• Quality of other beads	_____

Basic Skills

Reading

Critical Thinking

Technology

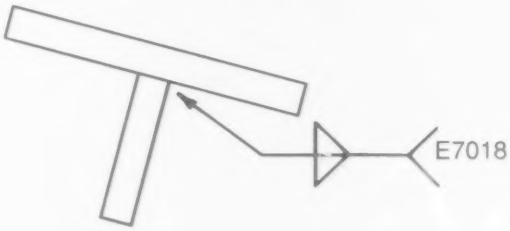
Tools, Equipment, and Materials

- SMAW machine with accessories
- Personal safety clothing and equipment
- Pliers
- Chipping hammer and wire brush
- Mild steel plates as selected by instructor
- Welding helmet and safety glasses

Specifications

1. Joint design and weld symbol:

   Figure 1



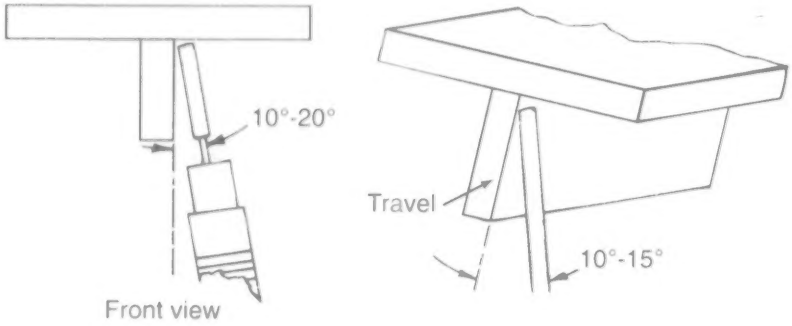
2. Filler metal and number of beads: E7018, 1/8″, 3/32″ or 5/32″, three passes
3. Electrical characteristics: DC+
4. Position: 4F

5. Direction of welding: N/A
6. Cleaning: Chip and wire brush
7. Testing: Visual
8. Technique: Drag

Procedure

- ❑ 1. Attach ground clamp to table or workpiece.
- ❑ 2. Select correct polarity for electrode.
- ❑ 3. Turn on welding machine.
- ❑ 4. Adjust to correct amperage by running short beads on scrap material.
- ❑ 5. Prepare plates as required to form the joint and tack weld both ends of the joint.
- ❑ 6. Place the joint so the weld will be in the correct position.
- ❑ 7. Place electrode in holder as indicated.

Figure 2



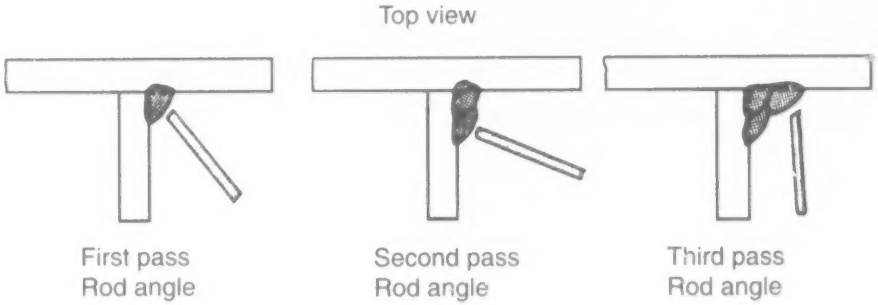
- ❑ 8. Start an arc and adjust electrode to correct arc length.
- ❑ 9. Adjust travel speed and electrode angle as required to make correct bead shape.
- ❑ 10. Weld the entire length of the joint; crater and backfill at the edge of the joint.
- ❑ 11. Secure the workpiece with pliers, and chip and brush the weld.

❑ 12. Inspect weld visually for undercutting, too much spatter, and bead shape.

❑ 13. Have your instructor check your work.

❑ 14. Weld other passes as required and be sure to clean and inspect each pass.

Figure 3



❑ 15. Have your instructor check your work.

❑ 16. Repeat procedure for other side of joint, if required by your instructor.

❑ 17. Clean and inspect all passes.

❑ 18. Have your instructor check your work.

❑ 19. Turn off machine.

❑ 20. Check in tools and materials and clean area, or prepare for next job sheet as directed by your instructor.

Evaluator's Comments: _____

_____

_____

Objective 66

Job Sheet 24—Weld to Specifications a V-Groove Butt Joint in the Flat Position with an E6010 Electrode

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• Bevel layout and cutting	_____
• Bevel grinding and preparation	_____
• First bead quality	_____
• Weld quality after bend test	_____

Basic Skills

Reading

Critical Thinking

Technology

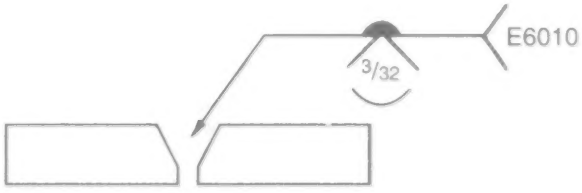
Tools, Equipment, and Materials

- SMAW machine with accessories
- Personal safety clothing and equipment
- Pliers
- Chipping hammer and wire brush
- Portable hand grinder
- Oxyacetylene cutting unit
- Soapstone
- Straightedge
- Cutting goggles
- Sparklighter
- File
- Mild steel plate, 3/8″
- Gap wire, 3/32″
- Bevel square
- Welding helmet and safety glasses

Specifications

1. Joint design and weld symbol:

Figure 1



2. Filler metal and number of beads: E6010, 1/8", 3/32" or 5/32"
3. Electrical characteristics: DC+
4. Position: 1G
5. Direction of welding: N/A
6. Cleaning: Chip and wire brush
7. Testing: Visual and bend test
8. Technique: Whipping

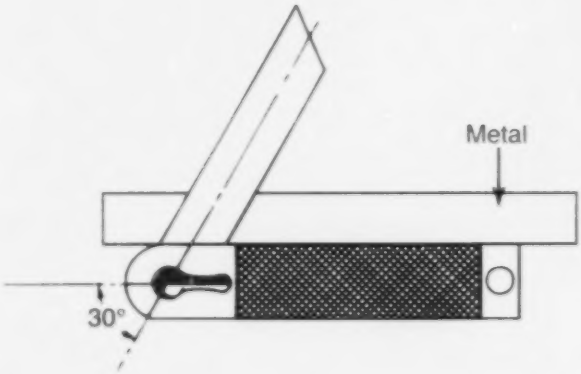
Procedure

❑ 1. Check work area to make sure it is free of flammable materials and well ventilated, and note the location of the nearest fire extinguisher.

❑ 2. Place plates to be beveled on cutting table.

❑ 3. Measure with the bevel square and mark the long side of the plate for a 30° bevel.

Figure 2



❑ 4. Light and adjust torch.

❑ 5. Place torch at a right angle to the plate and tilt 30° off the line to make the bevel cut on both plates.

Note: Beveling may be accomplished with a machine bevel, band saw or a track torch as directed by your instructor, and you may be directed to bevel several plates at this time in order to save time in future job sheets.

❑ 6. Turn off torch and secure system.

- ❑ 7. Secure plates in a vise one at a time, grind mill scale and slag from all surface areas to be welded, and be very careful to retain the 30° bevel angle.

- ❑ 8. Grind 1/16″ to 1/8″ root face (land) along the entire length of the thinnest part of the bevel on all plates.

- ❑ 9. Attach ground clamp to worktable or workpiece.

- ❑ 10. Select correct polarity for electrode.

- ❑ 11. Turn on machine.

- ❑ 12. Put on safety gear and adjust to correct amperage by running a few test beads on scrap metal.

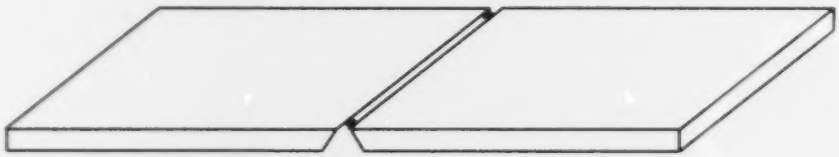
- ❑ 13. Align two plates face down on the work table, using a 3/32″ gap wire to properly align and space them.

- ❑ 14. Tack weld one end, remove gap wire, then align other end and tack weld

  Note: If you don't remove the gap wire prior to making the final tack, the wire will be difficult to remove.

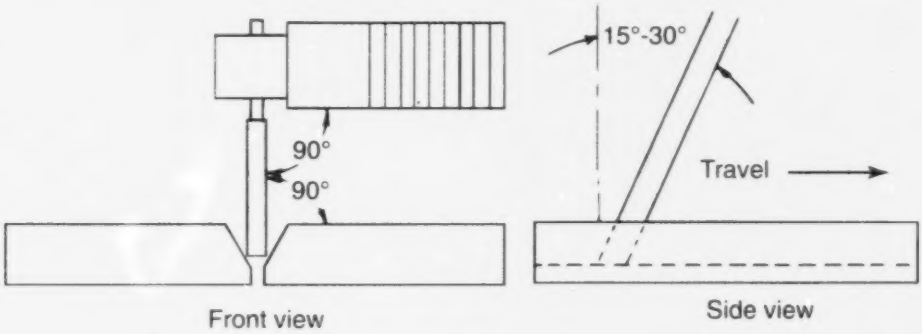
- ❑ 15. Position the plates so that the joint is in the position indicated in specifications.

Figure 3



❑ 16. Place electrode in holder and adjust to correct electrode angle over the joint.

Figure 4

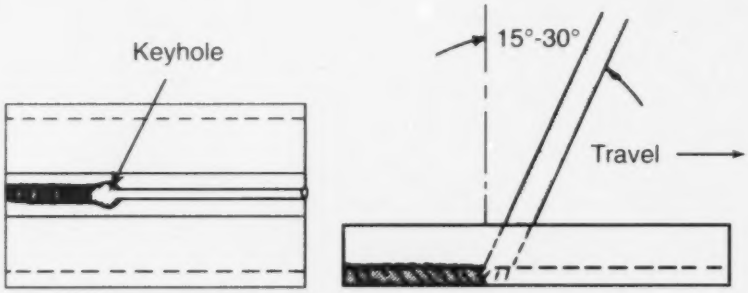


❑ 17. Start an arc and adjust electrode to correct arc length.

❑ 18. Make a puddle and immediately allow the keyhole to form.

Note: When the keyhole is properly formed, it allows the filler metal to completely penetrate the joint.

Figure 5



❑ 19. Whip the rod slightly forward to allow the keyhole to solidify, then whip the rod back to deposit more metal in the keyhole.

Note: Do not deposit filler metal outside the keyhole as you whip the rod away from the keyhole, and make sure your electrode is arcing in the bottom of the joint and not along the bevel.

❑ 20. Make a tie-in at any point where the electrode is used up with the following procedure:

❑ a. Clean slag off the pass just completed with the chipping hammer and a wire brush.

❑ b. Grind the root pass with a portable grinder, and feather the end of the pass so that it becomes a little thinner near the keyhole pass.

❑ 21. Restart the arc deep in the groove at a point no more than 1/4″ from the keyhole, and hold a long arc to heat that portion of the pass.

❑ 22. Make another puddle and immediately continue with the keyhole and the slight whipping motion back and forth to keep it moving.

❑ 23. Repeat the procedure as required until the joint is completely welded.

❑ 24. Secure workpiece with pliers and clean and inspect root pass on both sides to make sure penetration is 100%.

❑ 25. Grind the entire length of the root pass.

❑ 26. Increase amperage on welding machine about 5 to 10 amps (if required).

❑ 27. Use a whipping technique to run a second pass over the entire length of the root pass, taking care not to blow a hole through the root pass.

❑ 28. Secure workpiece with pliers and clean and inspect second pass to make sure it has good tie-in with the root pass.

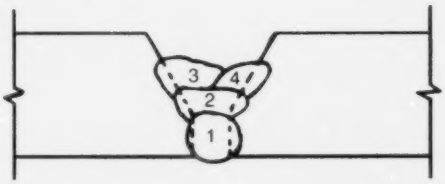
❑ 29. Grind the entire length of the second pass, if required.

❑ 30. Adjust amperage to proper setting for electrode.

❑ 31. Use a whipping technique to lay stringer beads for remainder of fill-up and clean each stringer before starting next pass.

Note: Numbers in the illustration indicate sequence, not quantity.

Figure 6

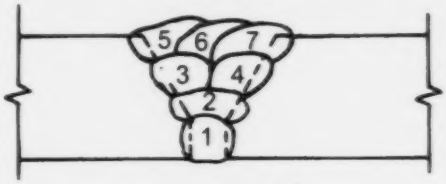


❑ 32. Clean fill-up stringer beads thoroughly to prepare for a cap pass.

❑ 33. Use a whipping technique to lay stringer beads for the cap.

Note: The total height of the cap pass should not exceed 1/8" and the sequence has to be followed carefully to accomplish this.

Figure 7



❑ 34. Clean and inspect cap pass.

❑ 35. Have your instructor check your work.

❑ 36. Turn off machine.

❑ 37. Bend test as directed in Job Sheet 25 and save practice workpieces for backgouging assignment in Unit 4.

❑ 38. Check in tools and materials and clean area, or prepare for next job sheet as directed by your instructor.

Evaluator's Comments: _____

_____

_____

Objective 67

Job Sheet 25—Bend Test a Welded V-Groove Joint

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• Specimens cut perpendicular to weld	_____
• Specimens ground in same direction as weld	_____
• Proper face bend test on plunger	_____
• Proper root bend test on plunger	_____
• Proper inspection of face and root bends	_____

Basic Skills

Reading Mathematics Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

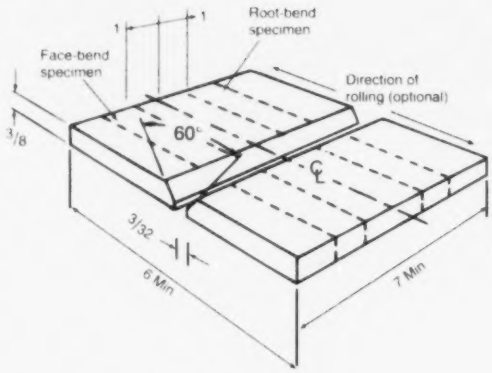
- Bend test machine
- Groove-weld test plate
- Oxyacetylene cutting unit
- Portable hand grinder
- File and pliers
- Personal safety clothing and equipment
- Soapstone and straightedge
- Cutting goggles and safety glasses
- Sparklighter

Procedure

❑ 1. Check work area to make sure it is free of flammable materials and well ventilated, and note the location of the nearest fire extinguisher.

❑ 2. Place test plate out on the worktable in front of you; use the straightedge and soapstone to mark off bend specimens for a face bend and a root bend; mark specimens F and R for identification.

Figure 1



❑ 3. Set up oxyacetylene equipment, light and adjust cutting flame, and cut the specimens perpendicular to the weld as marked.

❑ 4. Turn off torch and shut down cutting unit.

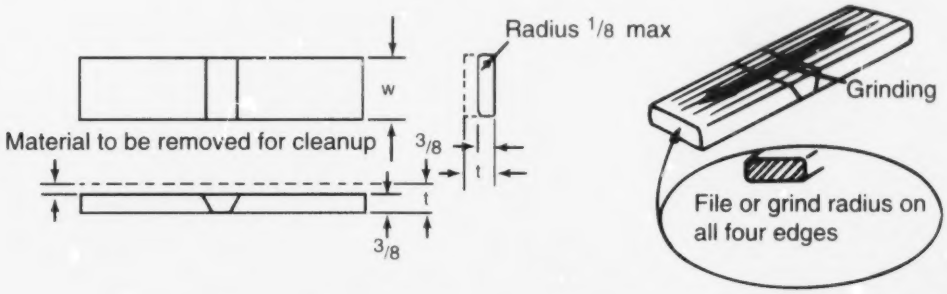
❑ 5. Permit specimens to air cool, but do not quench them in water or they will be unsuitable for testing.

❑ 6. Take cooled specimens one at a time, secure in a vise, and use a portable grinder to grind to the following specifications:

❑ a. A face bend specimen for a plunger-type tester should be a minimum of 6″ long, and 1 1/2″ wide, and should be ground in the same direction as the weld with the face of the weld flush with the surface of the specimen.

Note: A wrap-around tester will require a longer specimen.

Figure 2

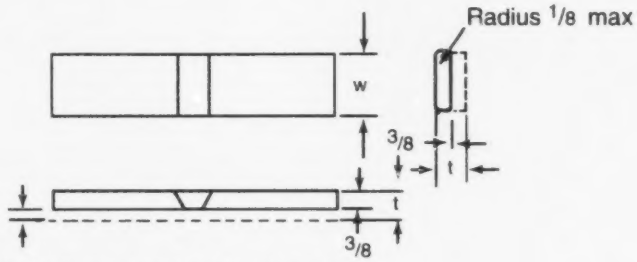


Courtesy of Lincoln Electric Company.

❑ b. A root bend specimen for a plunger-type tester should be a minimum of 6" long, and 1 1/2" wide, and should be ground in the same direction as the weld so that the root of the weld is flush with the surface of the specimen.

Note: A wrap-around tester will require a longer specimen.

Figure 3



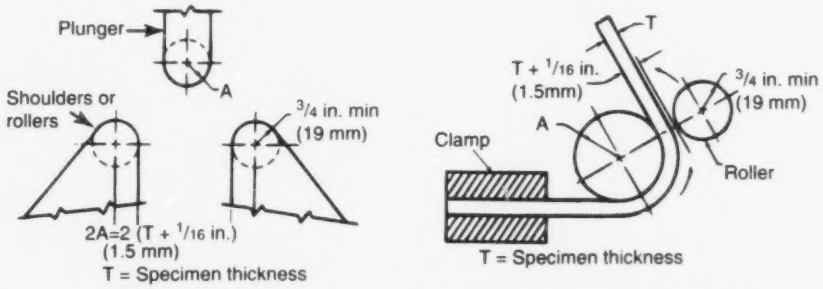
Material to be removed for cleanup

Courtesy of Lincoln Electric Company.

❑ 7. Grind or file the corners of both specimens so that they have a 1/8" radius.

❑ 8. Take specimens to plunger-type tester and make bends according to the following procedure:

Figure 4



Guided Bend Test Fixture

Wrap-Around Bend Test Fixture

Courtesy of American Welding Society.

❑ a. Place the face bend specimen on the die member of the fixture with the face of the weld pointing into the die so that the plunger is on the root side of the weld.

❑ b. Actuate the plunger to force the specimen between the plunger and the die until it is formed into a U shape.

> **Caution:** Always wear safety glasses when conducting bend tests.

❑ c. Release pressure on plunger to release the specimen from the die.

❑ 9. Repeat the testing procedure for the root bend, but reverse the root and face of the weld as you place it on the die.

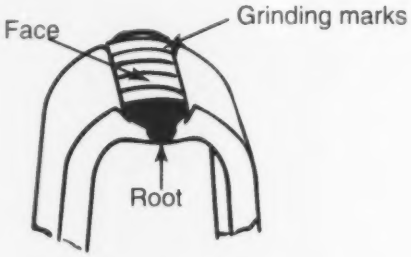
❑ 10. Inspect test specimens according to the following procedure:

❑ a. Examine convex surface of both specimens for cracks or other open defects.

❑ b. Check root bend to determine if weld has complete penetration through the joint.

❑ c. Check face bend to determine if there is complete fusion of the beveled edges with the weld.

Figure 5



❑ 11. Have your instructor check your bend test.

❑ 12. Check in tools and materials and clean area, or prepare for next job sheet as directed by your instructor.

Evaluator's Comments: _____

_____

_____

Objective 68

Job Sheet 26—Weld to Specifications a V-Groove Butt Joint in the Horizontal Position with an E6010 Electrode

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• Measuring and cutting joint	_____
• Root face preparation	_____
• Use of gap wire and tack welds	_____
• Root pass quality	_____
• Cleaning and inspection of passes	_____
• Total weld quality	_____

Basic Skills

Reading Mathematics Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

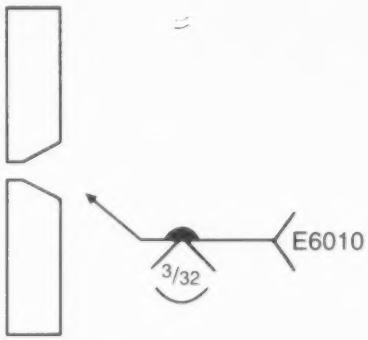
Tools, Equipment, and Materials

- SMAW machine with accessories
- Bend test machine
- Personal safety clothing, equipment, and glasses
- Pliers
- Chipping hammer and wire brush
- Portable hand grinder
- Oxyacetylene cutting unit
- Soapstone
- Straightedge
- Cutting goggles
- Sparklighter
- File
- Mild steel plate, as selected by instructor
- Gap wire, 3/32″
- Bevel square
- Welding helmet

Specifications

1. Joint design and weld symbol:

   Figure 1



2. Filler metal and number of beads: E6010, 3/32″ or 1/8″
3. Electrical characteristics: DC+
4. Position: 2G
5. Direction of welding: N/A
6. Cleaning: Chip, wire brush, and grind
7. Testing: Visual and bend test
8. Technique: Whipping

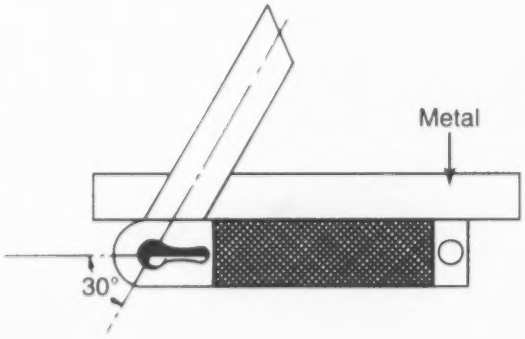
Procedure

❑ 1. Check work area to make sure it is free of flammable materials and well ventilated, and note the location of the nearest fire extinguisher.

❑ 2. Place plates to be beveled on cutting table.

❑ 3. Measure with the bevel square and mark the long side of the plate for a 30° bevel.

Figure 2



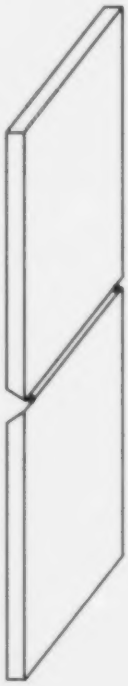
- ❑ 4. Light and adjust torch.
- ❑ 5. Place torch at a right angle to the plate and tilt 30° off the line to make the bevel cut on both plates.

  Note: Beveling may be accomplished with a machine bevel, band saw or a track torch as directed by your instructor, and you may be directed to bevel several plates at this time in order to save time in future job sheets.
- ❑ 6. Turn off torch and secure system.
- ❑ 7. Secure plates in a vise one at a time, grind mill scale and slag from all surface areas to be welded, and be very careful to retain the 30° bevel angle.
- ❑ 8. Grind 1/16″ to 1/8″ root face (land) along the entire length of the thinnest part of the bevel on all plates.
- ❑ 9. Attach ground clamp to worktable or workpiece.
- ❑ 10. Select correct polarity for electrode.
- ❑ 11. Turn on machine.
- ❑ 12. Put on safety gear and adjust to correct amperage by running a few test beads on scrap metal.
- ❑ 13. Align two plates face down on the work table, using a 3/32″ gap wire to properly align and space them.
- ❑ 14. Tack weld one end, remove gap wire, then align other end and tack weld.

  Note: If you don't remove the gap wire prior to making the final tack, the wire will be difficult to remove.

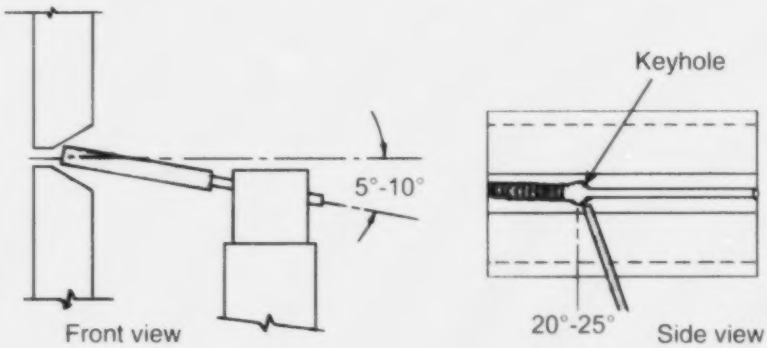
❑ 15. Position the plates so that the joint is in the position indicated in specifications.

Figure 3



❑ 16. Place electrode in holder and adjust to correct electrode angle over the joint.

Figure 4



❑ 17. Start an arc and adjust electrode to correct arc length.

❑ 18. Make a puddle and immediately allow the keyhole to form by pushing the electrode through the joint and keeping it flush with the backside of the joint.

Note: When the keyhole is properly formed, it allows the filler metal to completely penetrate the joint.

❑ 19. Whip the rod slightly forward to allow the keyhole to solidify, then whip the rod back to deposit more metal in the keyhole.

Note: Do not deposit filler metal outside the keyhole as you whip the rod away from the keyhole, and make sure your electrode is arcing in the bottom of the joint and not along the bevel.

❑ 20. Make a tie-in at any point where the electrode is used up with the following procedure:

❑ a. Clean slag off the pass just completed with the chipping hammer and a wire brush.

❑ b. Grind the root pass with a portable grinder, and feather the end of the pass so that it becomes a little thinner near the keyhole pass.

Note: Make other tie-ins with this same procedure.

❑ 21. Restart the arc deep in the groove at a point no more than 1/4" from the keyhole, and hold a long arc to heat that portion of the pass.

❑ 22. Make another puddle and immediately continue with the keyhole and the slight whipping motion back and forth to keep it moving.

❑ 23. Repeat the procedure as required until the joint is completely welded.

❑ 24. Secure workpiece with pliers and clean and inspect root pass on both sides to make sure penetration is 100%.

❑ 25. Grind the entire length of the root pass.

❑ 26. Increase amperage on welding machine about 5 to 10 amps (if required).

❑ 27. Use a whipping technique to run a second pass over the entire length of the root pass, taking care not to blow a hole through the root pass.

❑ 28. Secure workpiece with pliers and clean and inspect second pass to make sure it has good tie-in with the root pass.

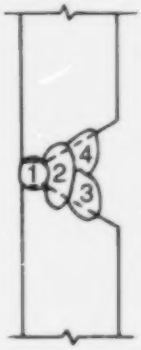
❑ 29. Grind the entire length of the second pass, if required.

❑ 30. Adjust amperage to proper setting for electrode.

❑ 31. Use a whipping technique to lay stringer beads for remainder of fill-up and clean each stringer before starting next pass.

Note: Numbers in the illustration indicate sequence, not quantity.

Figure 5



❑ 32. Clean fill-up stringer beads thoroughly to prepare for a cap pass.

❑ 33. Use a whipping technique to lay stringer beads for the cap so that they have a convex shape from the toes to the face of the cap.

Note: The total height of the cap pass should not exceed 1/8".

Figure 6

❑ 34. Clean and inspect cap pass.

❑ 35. Have your instructor check your work.

❑ 36. Turn off machine.

❑ 37. Bend test as directed in Job Sheet 25 and save practice workpieces for backgouging assignment in Unit 4.

❑ 38. Check in tools and materials and clean area, or prepare for next job sheet as directed by your instructor.

Evaluator's Comments: _____

_____

_____

Objective 69

Job Sheet 27—Weld to Specifications a V-Groove Butt Joint in the Vertical Position with an E6010 Electrode

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• Measuring and cutting joint	_____
• Root face preparation	_____
• Use of gap wire and tack welds	_____
• Root pass quality	_____
• Cleaning and inspection of passes	_____
• Total weld quality	_____

Basic Skills

Reading

Mathematics

Critical Thinking

Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

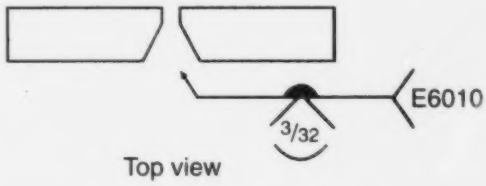
Tools, Equipment, and Materials

- SMAW machine with accessories
- Personal safety clothing
- Pliers
- Chipping hammer and wire brush
- Portable hand grinder
- Oxyacetylene cutting unit
- Soapstone
- Straightedge
- Cutting goggles
- Sparklighter
- File
- Mild steel plate, as selected by instructor
- Gap wire, 3/32″
- Bevel square
- Bend test machine
- Welding helmet and safety glasses

Specifications

1. Joint design and weld symbol:

   Figure 1



2. Filler metal and number of beads: E6010, 3/32″ or 1/8″
3. Electrical characteristics: DC+
4. Position: 3G
5. Direction of welding: Vertical up
6. Cleaning: Chip, wire brush, and grind
7. Testing: Visual and bend test
8. Technique: Whipping or weave bead

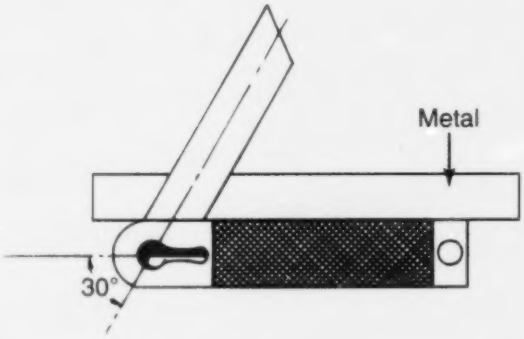
Procedure

❑ 1. Check work area to make sure it is free of flammable materials and well ventilated, and note the location of the nearest fire extinguisher.

❑ 2. Place plates to be beveled on cutting table.

❑ 3. Measure with the bevel square and mark the long side of the plate for a 30° bevel.

Figure 2



❑ 4. Light and adjust torch.

❑ 5. Place torch at a right angle to the plate and tilt 30° off the line to make the bevel cut on both plates.

Note: Beveling may be accomplished with a track torch as directed by your instructor, and you may be directed to bevel several plates at this time in order to save time in future job sheets.

❑ 6. Turn off torch and secure system.

❑ 7. Secure plates in a vise one at a time, grind mill scale and slag from all surface areas to be welded, and be very careful to retain the 30° bevel angle.

❑ 8. Grind 1/16″ to 1/8″ root face (land) along the entire length of the thinnest part of the bevel on all plates.

❑ 9. Attach ground clamp to worktable or workpiece.

❑ 10. Select correct polarity for electrode.

❑ 11. Turn on machine.

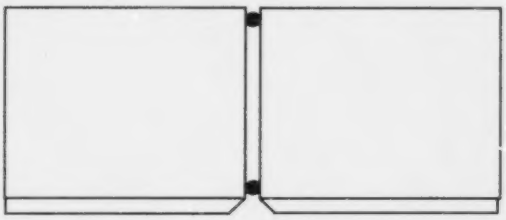
❑ 12. Put on safety gear and adjust to correct amperage by running a few test beads on scrap metal.

❑ 13. Align two plates face down on the work table, using a 3/32″ gap wire to properly align and space them.

❑ 14. Tack both ends of the joint and remove gap wire.

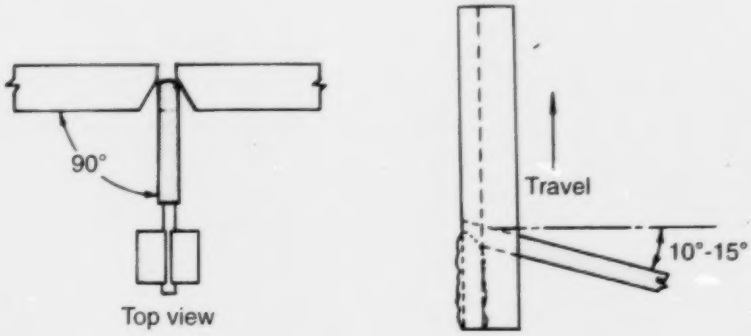
❑ 15. Position the plates so that the joint is in the position indicated in specifications.

Figure 3



❑ 16. Place electrode in holder and adjust to correct electrode angle over the joint.

Figure 4

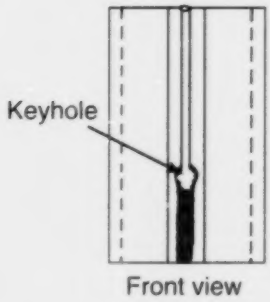


❑ 17. Start an arc and adjust electrode to correct arc length.

❑ 18. Make a puddle and immediately allow the keyhole to form.

Note: When the keyhole is properly formed, it allows the filler metal to completely penetrate the joint.

Figure 5



❑ 19. Whip the rod slightly forward to allow the keyhole to solidify, then whip the rod back to deposit more metal in the keyhole.

Note: Do not deposit filler metal outside the keyhole as you whip the rod away from the keyhole, and make sure your electrode is arcing in the bottom of the joint and not along the bevel.

❑ 20. Make a tie-in at any point where the electrode is used up with the following procedure:

❑ a. Clean slag off the pass just completed with the chipping hammer and a wire brush.

❑ b. Grind the root pass with a portable grinder, and feather the end of the pass so that it becomes a little thinner near the keyhole pass.

Note: Make other tie-ins with this same procedure.

❑ 21. Restart the arc deep in the groove at a point no more than 1/4" from the keyhole, and hold a long arc to heat that portion of the pass.

❑ 22. Make another puddle and immediately continue with the keyhole and the slight whipping motion back and forth to keep it moving.

❑ 23. Repeat the procedure as required until the joint is completely welded.

❑ 24. Secure workpiece with pliers and clean and inspect root pass on both sides to make sure penetration is 100%.

❑ 25. Grind the entire length of the root pass.

❑ 26. Increase amperage on welding machine about 5 to 10 amps (if required).

❑ 27. Use a whipping technique to run a second pass over the entire length of the root pass, taking care not to blow a hole through the root pass.

❑ 28. Secure workpiece with pliers and clean and inspect second pass to make sure it has good tie-in with the root pass.

❑ 29. Grind the entire length of the hot pass, if required.

❑ 30. Adjust amperage to proper setting for electrode.

❑ 31. Use a whipping or weave technique to lay stringer beads for remainder of fill-up and clean each stringer before starting next pass.

Note: Numbers in the illustration indicate sequence, not quantity.

Figure 6

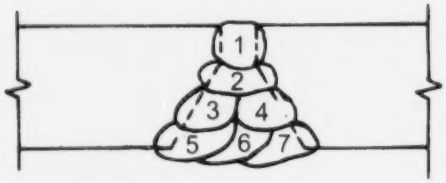
Top view

❑ 32. Clean fill-up stringer beads thoroughly to prepare for a cap pass.

❑ 33. Use a whipping technique or weave technique to lay beads for the cap.

Note: The total height of the cap pass should not exceed 1/8".

Figure 7



❑ 34. Clean and inspect cap pass.

❑ 35. Have your instructor check your work.

❑ 36. Turn off machine.

❑ 37. Bend test as specified and save practice workpieces for backgouging assignment in Unit 4.

❑ 38. Check in tools and materials and clean area, or prepare for next job sheet as directed by your instructor.

Evaluator's Comments: _____

_____

_____

308

Objective 70

Job Sheet 28—Weld to Specifications a V-Groove Butt Joint in the Overhead Position with an E6010 Electrode

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• Measuring and cutting joint	_____
• Root face preparation	_____
• Use of gap wire and tack welds	_____
• Root pass quality	_____
• Cleaning and inspection of passes	_____
• Total weld quality	_____

Basic Skills

Reading Mathematics Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

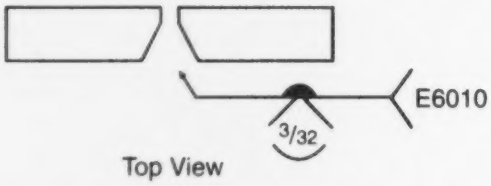
Tools, Equipment, and Materials

- SMAW machine with accessories
- Personal safety clothing
- Pliers
- Chipping hammer and wire brush
- Portable hand grinder
- Oxyacetylene cutting unit
- Soapstone
- Straightedge
- Cutting goggles
- Sparklighter
- File
- Mild steel plate, as selected by instructor
- Gap wire, 3/32″
- Bevel square
- Bend test machine
- Welding helmet and safety glasses

Specifications

1. Joint design and weld symbol:

   Figure 1



2. Filler metal and number of beads: E6010, 3/32″ or 1/8″
3. Electrical characteristics: DC+
4. Position: 4G
5. Direction of welding: N/A
6. Cleaning: Chip, wire brush, and grind
7. Testing: Visual and bend test
8. Technique: Whipping

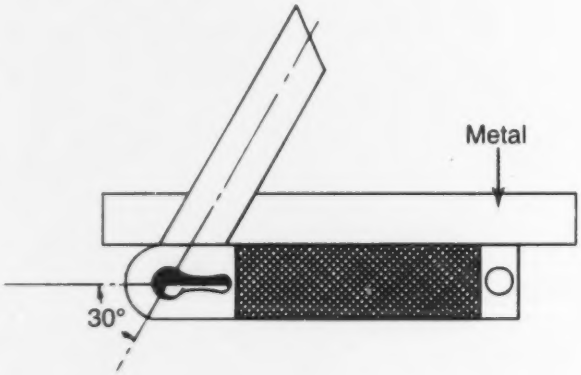
Procedure

❑ 1. Check work area to make sure it is free of flammable materials and well ventilated, and note the location of the nearest fire extinguisher.

❑ 2. Place plates to be beveled on cutting table.

❑ 3. Measure with the bevel square and mark the long side of the plate for a 30° bevel.

Figure 2



❑ 4. Light and adjust torch.

310

- ❑ 5. Place torch at a right angle to the plate and tilt 30° off the line to make the bevel cut on both plates.

  Note: Beveling may be accomplished with a machine bevel, band saw or a track torch as directed by your instructor, and you may be directed to bevel several plates at this time in order to save time in future job sheets.

- ❑ 6. Turn off torch and secure system.

- ❑ 7. Secure plates in a vise one at a time, grind mill scale and slag from all surface areas to be welded, and be very careful to retain the 30° bevel angle.

- ❑ 8. Grind 1/16″ to 1/8″ root face (land) along the entire length of the thinnest part of the bevel on all plates.

- ❑ 9. Attach ground clamp to worktable or workpiece.

- ❑ 10. Select correct polarity for electrode.

- ❑ 11. Turn on machine.

- ❑ 12. Put on safety gear and adjust to correct amperage by running a few test beads on scrap metal.

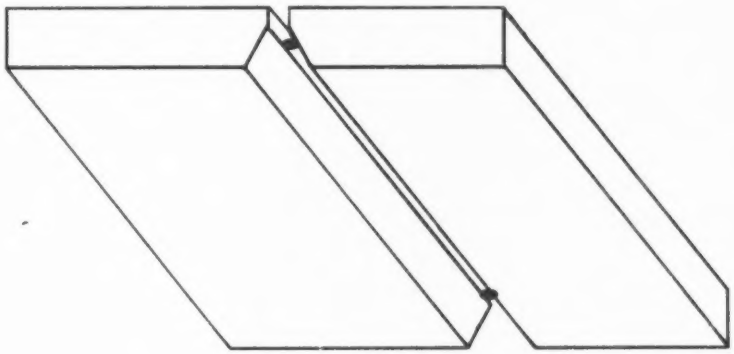
- ❑ 13. Align two plates face down on the work table, using a 3/32″ gap wire to properly align and space them.

- ❑ 14. Tack weld one end, remove gap wire, then align the other end and tack weld.

  Note: If you don't remove the gap wire prior to making the final tack, the wire will be difficult to remove.

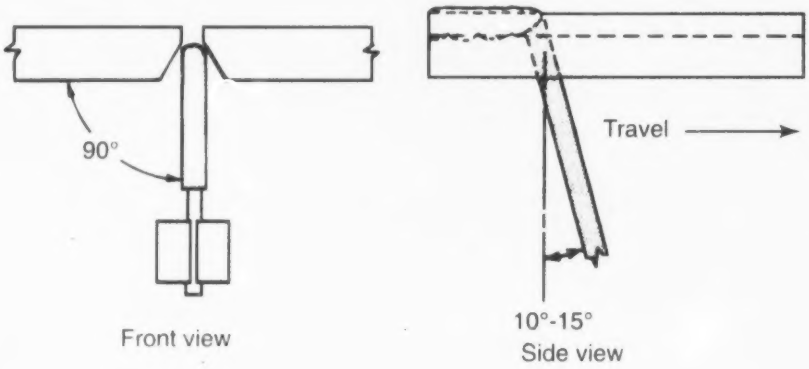
- ❑ 15. Position the plates so that the joint is in the position indicated in specifications.

Figure 3



❑ 16. Place electrode in holder and adjust to correct electrode angle over the joint.

Figure 4

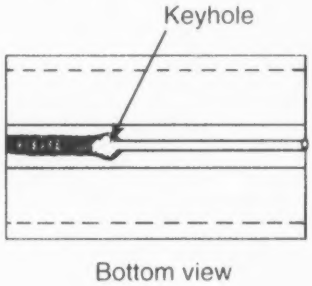


❑ 17. Start an arc and adjust electrode to correct arc length.

❑ 18. Make a puddle and immediately allow the keyhole to form.

Note: When the keyhole is properly formed, it allows the filler metal to completely penetrate the joint.

Figure 5



❑ 19. Whip the rod slightly forward to allow the keyhole to solidify, then whip the rod back to deposit more metal in the keyhole.

Note: Do not deposit filler metal outside the keyhole as you whip the rod away from the keyhole, and make sure your electrode is arcing in the bottom of the joint and not along the bevel.

❑ 20. Make a tie-in at any point where the electrode is used up with the following procedure:

❑ a. Clean slag off the pass just completed with the chipping hammer and a wire brush.

❑ b. Grind the root pass with a portable grinder, and feather the end of the pass so that it becomes a little thinner near the keyhole pass.

❑ 21. Restart the arc deep in the groove at a point no more than 1/4″ from the keyhole, and hold a long arc to heat that portion of the pass.

❑ 22. Make another puddle and immediately continue with the keyhole and the slight whipping motion back and forth to keep it moving.

❑ 23. Repeat the procedure as required until the joint is completely welded.

❑ 24. Secure workpiece with pliers and clean and inspect root pass on both sides to make sure penetration is 100%.

❑ 25. Grind the entire length of the root pass.

❑ 26. Increase amperage on welding machine about 5 to 10 amps (if required).

❑ 27. Use a whipping technique to run a second pass over the entire length of the root pass, taking care not to blow a hole through the root pass.

❑ 28. Secure workpiece with pliers and clean and inspect second pass to make sure it has good tie-in with the root pass.

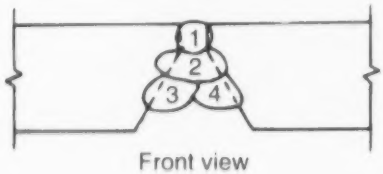
❑ 29. Grind the entire length of the second pass, if required.

❑ 30. Adjust amperage to proper setting for electrode.

❑ 31. Use a whipping technique to lay stringer beads for remainder of fill-up and clean each stringer before starting next pass.

Note: Numbers in the illustration indicate sequence, not quantity.

Figure 6



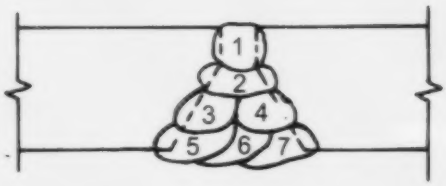
Front view

❑ 32. Clean fill-up stringer beads thoroughly to prepare for a cap pass.

❑ 33. Use a whipping technique to lay beads for the cap.

Note: The total height of the cap pass should not exceed 1/8" and the sequence has to be followed carefully to accomplish this.

Figure 7



❑ 34. Clean and inspect cap pass.

❑ 35. Have your instructor check your work.

❑ 36. Turn off machine.

❑ 37. Bend test as specified and save practice workpieces for backgouging assignment in Unit 4.

❑ 38. Check in tools and materials and clean area, or prepare for next job sheet as directed by your instructor.

Evaluator's Comments: _____

_____

_____

314

Objective 71

Job Sheet 29—Weld to Specifications a V-Groove Butt Joint in the Flat Position with an E6010 Electrode Root and an E7018 Electrode Fill and Cap

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• Joint and root face preparation	_____
• Root face quality	_____
• Use of gap wire and tack welds	_____
• Root pass quality	_____
• Second and other pass quality with E7018	_____
• Final weld quality	_____

Basic Skills

Reading Mathematics Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

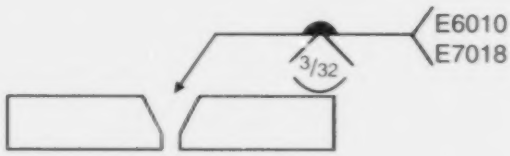
Tools, Equipment, and Materials

- SMAW machine with accessories
- Personal safety clothing
- Pliers
- Chipping hammer and wire brush
- Portable hand grinder
- Oxyacetylene cutting unit
- Soapstone
- Straightedge
- Cutting goggles
- Sparklighter
- File
- Mild steel plate, as selected by instructor
- Gap wire, 3/32″
- Bevel square
- Bend test machine
- Welding helmet and safety glasses

Specifications

1. Joint design and weld symbol:

   Figure 1



2. Filler metal and number of beads: E6010, E7018, 3/32″ or 1/8″
3. Electrical characteristics: DC+
4. Position: 1G
5. Direction of welding: N/A
6. Cleaning: Chip, wire brush, and grind
7. Testing: Visual and bend test
8. Technique: Whip and drag

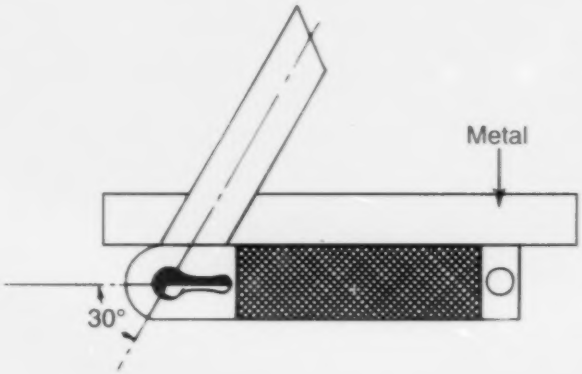
Procedure

❑ 1. Check work area to make sure it is free of flammable materials and well ventilated, and note the location of the nearest fire extinguisher.

❑ 2. Place plates to be beveled on cutting table.

❑ 3. Measure with the bevel square and mark the long side of the plate for a 30° bevel.

Figure 2



❑ 4. Light and adjust torch.

- ❑ 5. Place torch at a right angle to the plate and tilt 30° off the line to make the bevel cut on both plates.

  Note: Beveling may be accomplished with a machine bevel, a band saw or a track torch as directed by your instructor, and you may be directed to bevel several plates at this time in order to save time in future job sheets.

- ❑ 6. Turn off torch and secure system.

- ❑ 7. Secure plates in a vise one at a time, grind mill scale and slag from all surface areas to be welded, and be very careful to retain the 30° bevel angle.

- ❑ 8. Grind 1/16″ to 1/8″ root face (land) along the entire length of the thinnest part of the bevel on all plates.

- ❑ 9. Attach ground clamp to worktable or workpiece.

- ❑ 10. Select correct polarity for electrode.

- ❑ 11. Turn on machine.

- ❑ 12. Put on safety gear and adjust to correct amperage by running a few test beads on scrap metal.

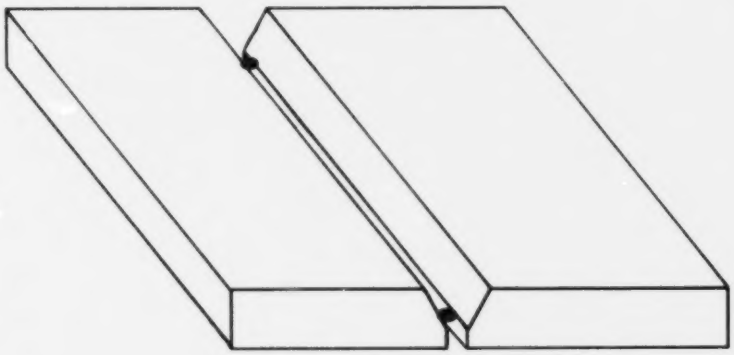
- ❑ 13. Align two plates face down on the work table, using a 3/32″ gap wire to properly align and space them.

- ❑ 14. Tack weld one end, remove gap wire, then align the other end and tack weld.

  Note: If you don't remove the gap wire prior to making the final tack, the wire will be difficult to remove.

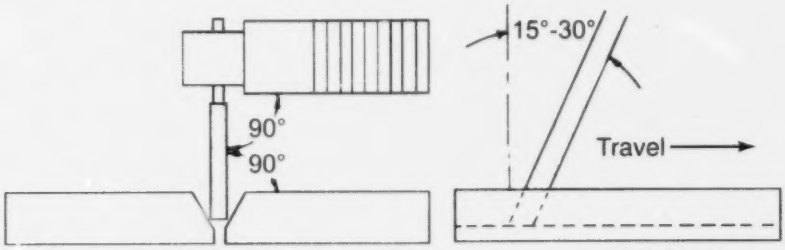
- ❑ 15. Position the plates so that the joint is in the position indicated in specifications.

Figure 3



❑ 16. Place electrode in holder and adjust to correct electrode angle over the joint.

Figure 4



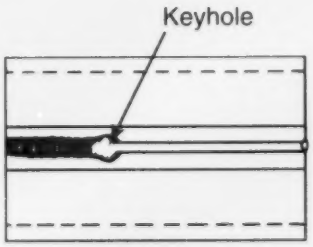
Front view Side view

❑ 17. Start an arc and adjust electrode to correct arc length.

❑ 18. Make a puddle and immediately allow the keyhole to form.

Note: When the keyhole is properly formed, it allows the filler metal to completely penetrate the joint.

Figure 5



Top view

318

❑ 19. Whip the rod slightly forward to allow the keyhole to solidify, then whip the rod back to deposit more metal in the keyhole.

Note: Do not deposit filler metal outside the keyhole as you whip the rod away from the keyhole, and make sure your electrode is arcing in the bottom of the joint and not along the bevel.

❑ 20. Make a tie-in at any point where the electrode is used up with the following procedure:

❑ a. Clean slag off the pass just completed with the chipping hammer and a wire brush.

❑ b. Grind the root pass with a portable grinder, and feather the end of the pass so that it becomes a little thinner near the keyhole pass.

❑ 21. Restart the arc deep in the groove at a point no more than 1/4" from the keyhole, and hold a long arc to heat that portion of the pass.

❑ 22. Make another puddle and immediately continue with the keyhole and the slight whipping motion back and forth to keep it moving.

❑ 23. Repeat the procedure as required until the joint is completely welded.

❑ 24. Secure workpiece with pliers and clean and inspect root pass on both sides to make sure penetration is 100%.

❑ 25. Grind the entire length of the root pass.

❑ 26. Adjust amperage to proper setting for an E7018 electrode.

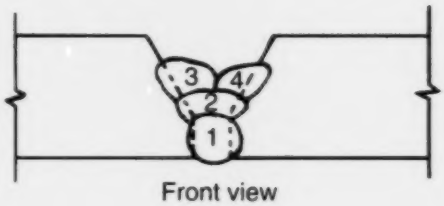
❑ 27. Use a drag technique to run a second pass over the entire length of the root pass, taking care not to blow a hole through the root pass.

❑ 28. Secure workpiece with pliers and clean and inspect second pass to make sure it has good tie-in with the root pass.

❑ 29. Use a drag technique to lay stringer beads for remainder of fill-up and clean each stringer before starting next pass.

Note: Numbers in the illustration indicate sequence, not quantity.

Figure 6



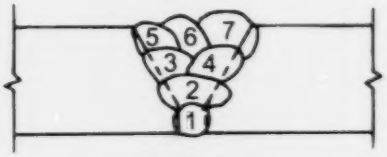
Front view

❑ 30. Clean fill-up stringer beads thoroughly to prepare for a cap pass.

❑ 31. Use a drag technique to lay stringer beads for the cap.

Note: The total height of the cap pass should not exceed 1/8" and the sequence has to be followed carefully to accomplish this.

Figure 7



Front view

❑ 32. Clean and inspect cap pass.

❑ 33. Have your instructor check your work.

❑ 34. Turn off machine.

❑ 35. Bend test as specified and save practice workpieces for backgouging assignment in Unit 4.

❑ 36. Check in tools and materials and clean area, or prepare for next job sheet as directed by your instructor.

Evaluator's Comments: _____

_____

_____

Objective 72

Job Sheet 30—Weld to Specifications a V-Groove Butt Joint in the Horizontal Position with an E6010 Electrode Root and an E7018 Electrode Fill and Cap

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• Joint and root face preparation	_____
• Use of gap wire and tack welds	_____
• Root pass quality with E6010	_____
• Second and other pass quality with E7018	_____
• Final weld quality	_____

Basic Skills

Reading Mathematics Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

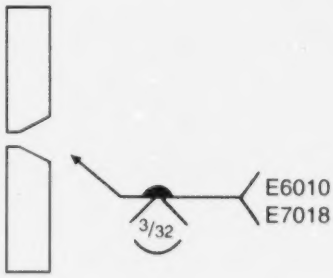
Tools, Equipment, and Materials

- SMAW machine with accessories
- Personal safety clothing
- Pliers
- Chipping hammer and wire brush
- Portable hand grinder
- Oxyacetylene cutting unit
- Soapstone
- Straightedge
- Cutting goggles
- Sparklighter
- File
- Mild steel plate, as selected by instructor
- Gap wire, 3/32″
- Bevel square
- Bend test machine
- Welding helmet and safety glasses

Specifications

1. Joint design and weld symbol:

   Figure 1



2. Filler metal and number of beads: E6010, E7018, 3/32″ or 1/8″
3. Electrical characteristics: DC+
4. Position: 2G
5. Direction of welding: N/A
6. Cleaning: Chip, wire brush, and grind
7. Testing: Visual and bend test
8. Technique: Whip and drag

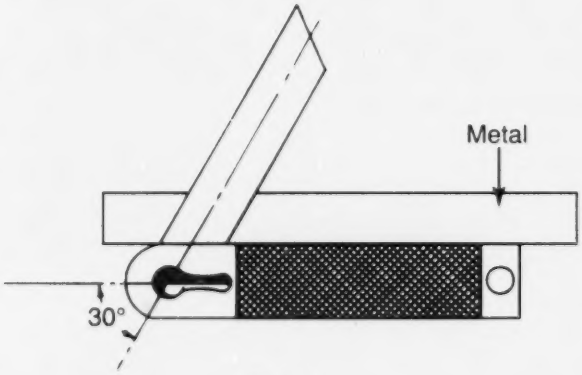
Procedure

❑ 1. Check work area to make sure it is free of flammable materials and well ventilated, and note the location of the nearest fire extinguisher.

❑ 2. Place plates to be beveled on cutting table.

❑ 3. Measure with the bevel square and mark the long side of the plate for a 30° bevel.

Figure 2



3-2

- ❑ 4. Light and adjust torch.
- ❑ 5. Place torch at a right angle to the plate and tilt 30° off the line to make the bevel cut on both plates.

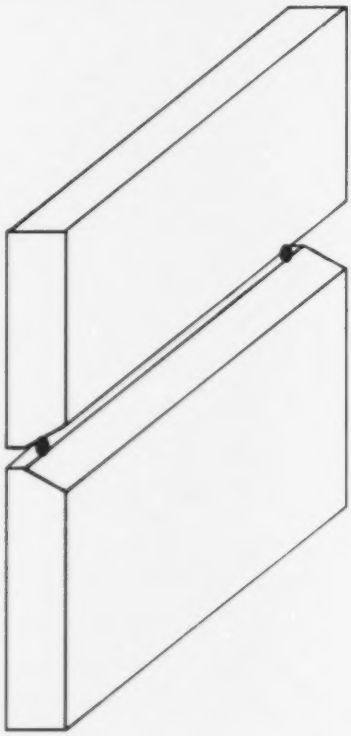
  Note: Beveling may be accomplished with a machine bevel, band saw, or a track torch as directed by your instructor, and you may be directed to bevel several plates at this time in order to save time in future job sheets.

- ❑ 6. Turn off torch and secure system.
- ❑ 7. Secure plates in a vise one at a time, grind mill scale and slag from all surface areas to be welded, and be very careful to retain the 30° bevel angle.
- ❑ 8. Grind 1/16" to 1/8" root face (land) along the entire length of the thinnest part of the bevel on all plates.
- ❑ 9. Attach ground clamp to worktable or workpiece.
- ❑ 10. Select correct polarity for electrode.
- ❑ 11. Turn on machine.
- ❑ 12. Put on safety gear and adjust to correct amperage by running a few test beads on scrap metal.
- ❑ 13. Align two plates face down on the work table, using a 3/32" gap wire to properly align and space them.
- ❑ 14. Tack weld one end, remove gap wire, then align the other end and tack weld.

  Note: If you don't remove the gap wire prior to making the final weld, the wire will be difficult to remove.

❑ 15. Position the plates so that the joint is in the position indicated in specifications.

Figure 3



❑ 16. Make a tie-in at any point where the electrode is used up with the following procedure.

❑ a. Clean slag off the pass just completed with the chipping hammer and a wire brush.

❑ b. Grind the root pass with a portable grinder, and feather the end of the pass so that it becomes a little thinner near the keyhole pass.

Note: Make other tie-ins with this same procedure.

❑ 17. Restart the arc deep in the groove at a point no more than 1/4" from the keyhole, and hold a long arc to heat that portion of the pass.

❑ 18. Make another puddle and immediately continue with the keyhole and the slight whipping motion back and forth to keep it moving.

❑ 19. Repeat the procedure as required until the joint is completely welded.

❑ 20. Secure workpiece with pliers and clean and inspect root pass on both sides to make sure penetration is 100%.

❑ 21. Grind the entire length of the root pass.

❑ 22. Adjust amperage to proper setting for an E7018 electrode.

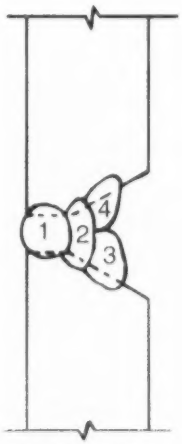
❑ 23. Use a drag technique to run a second pass over the entire length of the root pass, taking care not to blow a hole through the root pass.

❑ 24. Secure workpiece with pliers and clean and inspect second pass to make sure it has good tie-in with the root pass.

❑ 25. Use a drag technique to lay stringer beads for remainder of fill-up and clean each stringer before starting next pass.

Note: Numbers in the illustration indicate sequence, not quantity.

Figure 4



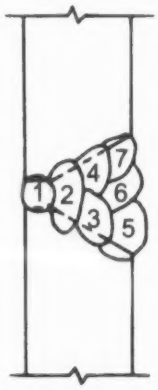
Front view

❑ 26. Clean fill-up stringer beads thoroughly to prepare for a cap pass.

❑ 27. Use a drag technique to lay stringer beads for the cap.

Note: The total height of the cap pass should not exceed 1/8" and the sequence has to be followed carefully to accomplish this.

Figure 5



Front view

❑ 28. Clean and inspect cap pass.

❑ 29. Have your instructor check your work.

❑ 30. Turn off machine.

❑ 31. Bend test as specified and save practice workpieces for backgouging assignment in Unit 4.

❑ 32. Check in tools and materials and clean area, or prepare for next job sheet as directed by your instructor.

Evaluator's Comments: _____

_____

_____

Objective 73

Job Sheet 31—Weld to Specifications a V-Groove Butt Joint in the Vertical Position with an E6010 Electrode Root and an E7018 Electrode Fill and Cap

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• Joint and root face preparation	_____
• Use of gap wire and tack welds	_____
• Root pass quality with E6010	_____
• Second and other pass quality with E7018	_____
• Final weld quality	_____

Basic Skills

Reading Mathematics Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

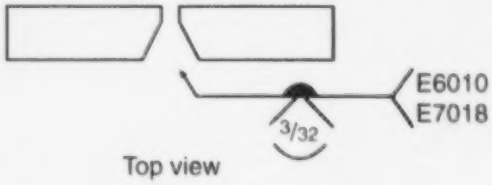
Tools, Equipment, and Materials

- SMAW machine with accessories
- Personal safety clothing
- Pliers
- Chipping hammer and wire brush
- Portable hand grinder
- Oxyacetylene cutting unit
- Soapstone
- Straightedge
- Cutting goggles
- Sparklighter
- File
- Mild steel plate, as selected by instructor
- Gap wire, 3/32″
- Bevel square
- Bend test machine
- Welding helmet and safety glasses

Specifications

1. Joint design and weld symbol:

   Figure 1



2. Filler metal and number of beads: E6010, E7018, 3/32″ or 1/8″
3. Electrical characteristics: DC+
4. Position: 3G
5. Direction of welding: Vertical up
6. Cleaning: Chip, wire brush, and grind
7. Testing: Visual and bend test
8. Technique: Whip, stringer, or weave

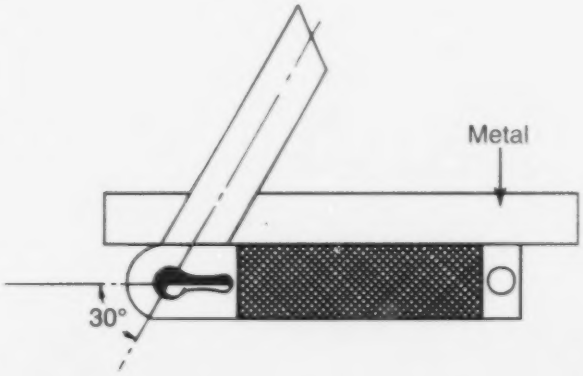
Procedure

❑ 1. Check work area to make sure it is free of flammable materials and well ventilated, and note the location of the nearest fire extinguisher.

❑ 2. Place plates to be beveled on cutting table.

❑ 3. Measure with the bevel square and mark the long side of the plate for a 30° bevel.

Figure 2

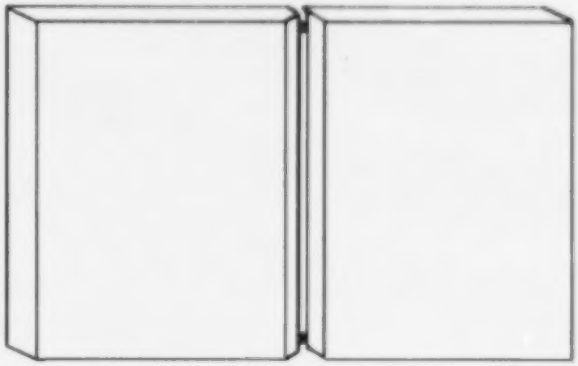


- ❑ 4. Light and adjust torch.
- ❑ 5. Place torch at a right angle to the plate and tilt 30° off the line to make the bevel cut on both plates.

  Note: Beveling may be accomplished with a machine bevel, band saw, or a track torch as directed by your instructor, and you may be directed to bevel several plates at this time in order to save time in future job sheets.
- ❑ 6. Turn off torch and secure system.
- ❑ 7. Secure plates in a vise one at a time, grind mill scale and slag from all surface areas to be welded, and be very careful to retain the 30° bevel angle.
- ❑ 8. Grind 1/16" to 1/8" root face (land) along the entire length of the thinnest part of the bevel on all plates.
- ❑ 9. Attach ground clamp to worktable or workpiece.
- ❑ 10. Select correct polarity for electrode.
- ❑ 11. Turn on machine.
- ❑ 12. Put on safety gear and adjust to correct amperage by running a few test beads on scrap metal.
- ❑ 13. Align two plates face down on the work table, using a 3/32" gap wire to properly align and space them.
- ❑ 14. Tack weld one end, remove gap wire, then align the other end and tack weld.

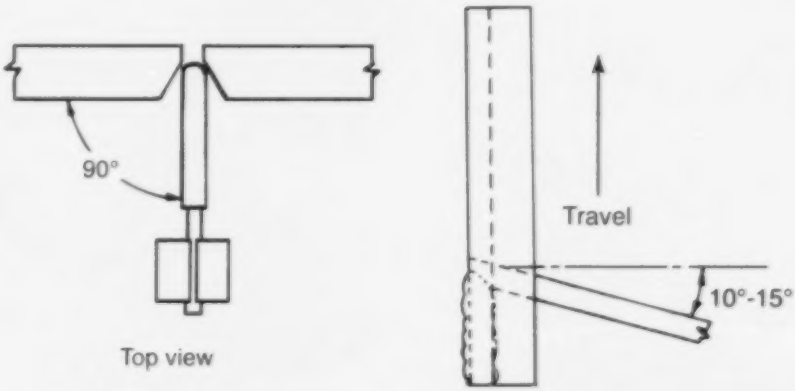
  Note: If you don't remove the gap wire prior to the final weld, the wire will be difficult to remove.
- ❑ 15. Position the plates so that the joint is in the position indicated in specifications.

Figure 3



❑ 16. Place electrode in holder and adjust to correct electrode angle over the joint.

Figure 4



Top view

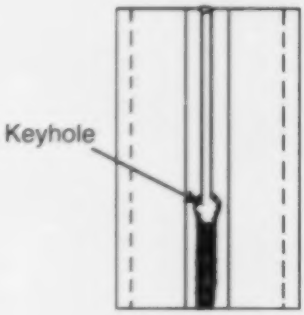
Side view

❑ 17. Start an arc and adjust electrode to correct arc length.

❑ 18. Make a puddle and immediately allow the keyhole to form.

Note: When the keyhole is properly formed, it allows the filler metal to completely penetrate the joint.

Figure 5



Front view

❑ 19. Whip the rod slightly forward to allow the keyhole to solidify, then whip the rod back to deposit more metal in the keyhole.

Note: Do not deposit filler metal outside the keyhole as you whip the rod away from the keyhole, and make sure your electrode is arcing in the bottom of the joint and not along the bevel.

❑ 20. Make a tie-in at any point where the electrode is used up with the following procedure:

❑ a. Clean slag off the pass just completed with the chipping hammer and a wire brush.

❑ b. Grind the root pass with a portable grinder, and feather the end of the pass so that it becomes a little thinner near the keyhole pass.

❑ 21. Restart the arc deep in the groove at a point no more than 1/4" from the keyhole, and hold a long arc to heat that portion of the pass.

❑ 22. Make another puddle and immediately continue with the keyhole and the slight whipping motion back and forth to keep it moving.

❑ 23. Repeat the procedure as required until the joint is completely welded.

❑ 24. Secure workpiece with pliers and clean and inspect root pass on both sides to make sure penetration is 100%.

❑ 25. Grind the entire length of the root pass.

❑ 26. Adjust amperage to proper setting for an E7018 electrode.

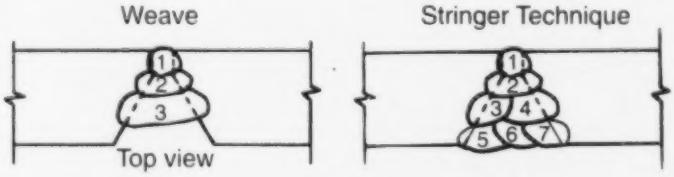
❑ 27. Use a weave technique to run a second pass over the entire length of the root pass, taking care not to blow a hole through the root pass.

❑ 28. Secure workpiece with pliers and clean and inspect second pass to make sure it has good tie-in with the root pass.

❑ 29. Use a weave or stringer technique to lay beads for remainder of fill-up, and clean each pass before starting next pass.

Note: Numbers in the illustration indicate sequence, not quantity. Your instructor may direct you to use a weaving or stringer technique on fill and cap beads.

Figure 6

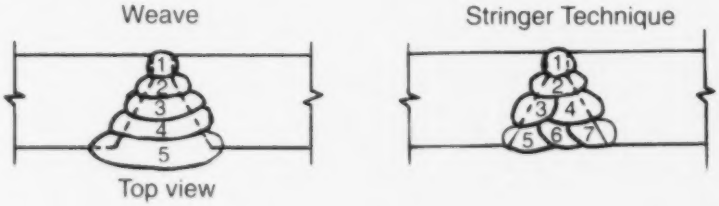


❑ 30. Clean fill-up stringer beads thoroughly to prepare for a cap pass.

❑ 31. Use a weaving or stringer technique to lay beads for the cap.

Note: The total height of the cap pass should not exceed 1/8" and the sequence has to be followed carefully to accomplish this.

Figure 7



❑ 32. Clean and inspect cap pass.

❑ 33. Have your instructor check your work.

❑ 34. Turn off machine.

❑ 35. Bend test as specified. (Refer to Job Sheet 25.)

❑ 36. Check in tools and materials and clean area, or prepare for next job sheet as directed by your instructor.

Evaluator's Comments: _____

_____

_____

332

Objective 74

Job Sheet 32—Weld to Specifications a V-Groove Butt Joint in the Overhead Position with an E6010 Electrode Root and an E7018 Electrode Fill and Cap

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• Joint and root face preparation	_____
• Use of gap wire and tack welds	_____
• Root pass quality with E6010	_____
• Second and other pass quality with E7018	_____
• Final weld quality	_____

Basic Skills

Reading Mathematics Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

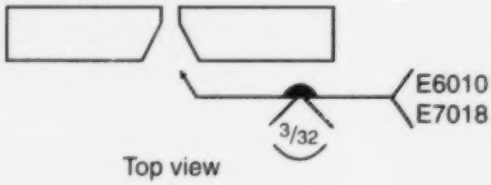
Tools, Equipment, and Materials

- SMAW machine with accessories
- Personal safety clothing and equipment
- Pliers
- Chipping hammer and wire brush
- Portable hand grinder
- Oxyacetylene cutting unit
- Soapstone
- Straightedge
- Cutting goggles
- Sparklighter
- File
- Mild steel plate, as selected by instructor
- Gap wire, 3/32"
- Bevel square
- Bend test machine
- Welding helmet and safety glasses

Specifications

1. Joint design and weld symbol:

   Figure 1



2. Filler metal and number of beads: E6010, E7018, 3/32″ or 1/8″
3. Electrical characteristics: DC+
4. Position: 4G
5. Direction of welding: N/A
6. Cleaning: Chip, wire brush, and grind
7. Testing: Visual and bend test
8. Technique: Whip and drag

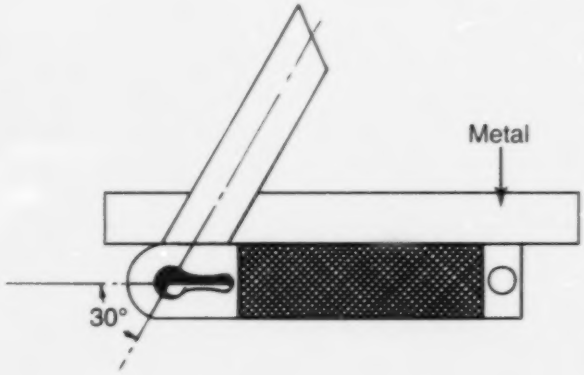
Procedure

❑ 1. Check work area to make sure it is free of flammable materials and well ventilated, and note the location of the nearest fire extinguisher.

❑ 2. Place plates to be beveled on cutting table.

❑ 3. Measure with the bevel square and mark the long side of the plate for a 30° bevel.

Figure 2



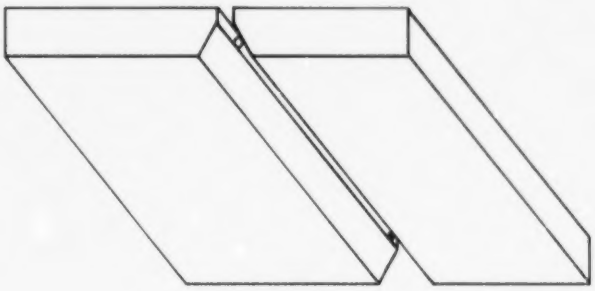
- ❑ 4. Light and adjust torch.
- ❑ 5. Place torch at a right angle to the plate and tilt 30° off the line to make the bevel cut on both plates.

  Note: Beveling may be accomplished with a machine bevel, a band saw, or a track torch as directed by your instructor, and you may be directed to bevel several plates at this time in order to save time in future job sheets.
- ❑ 6. Turn off torch and secure system.
- ❑ 7. Secure plates in a vise one at a time, grind mill scale and slag from all surface areas to be welded, and be very careful to retain the 30° bevel angle.
- ❑ 8. Grind 1/16″ to 1/8″ root face (land) along the entire length of the thinnest part of the bevel on all plates.
- ❑ 9. Attach ground clamp to worktable or workpiece.
- ❑ 10. Select correct polarity for electrode.
- ❑ 11. Turn on machine.
- ❑ 12. Put on safety gear and adjust to correct amperage by running a few test beads on scrap metal.
- ❑ 13. Align two plates face down on the work table, using a 3/32″ gap wire to properly align and space them.
- ❑ 14. Tack weld one end, remove gap wire, then align other end and tack weld.

  Note: If you don't remove gap wire prior to final weld, the wire will be difficult to remove.
- ❑ 15. Position the plates so that the joint is in the position indicated in specifications.

335

Figure 3



❑ 16. Make a tie-in at any point where the electrode is used up with the following procedure.

❑ a. Clean slag off the pass just completed with the chipping hammer and a wire brush.

❑ b. Grind the root pass with a portable grinder, and feather the end of the pass so that it becomes a little thinner near the keyhole pass.

Note: Make other tie-ins with this same procedure.

❑ 17. Restart the arc deep in the groove at a point no more than 1/4" from the keyhole, and hold a long arc to heat that portion of the pass.

❑ 18. Make another puddle and immediately continue with the keyhole and the slight whipping motion back and forth to keep it moving.

❑ 19. Repeat the procedure as required until the joint is completely welded.

❑ 20. Secure workpiece with pliers and clean and inspect root pass on both sides to make sure penetration is 100%.

❑ 21. Grind the entire length of the root pass.

❑ 22. Adjust amperage to proper setting for an E7018 electrode.

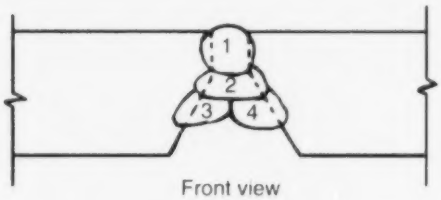
❑ 23. Use a drag technique to run a second pass over the entire length of the root pass, taking care not to blow a hole through the root pass.

❑ 24. Secure workpiece with pliers and clean and inspect second pass to make sure it has good tie-in with the root pass.

❑ 25. Use a drag technique to lay stringer beads for remainder of fill-up and clean each stringer before starting next pass.

Note: Numbers in the illustration indicate sequence, not quantity.

Figure 4



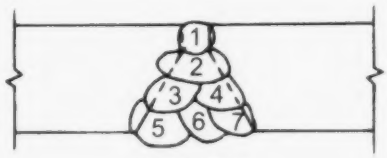
Front view

❑ 26. Clean fill-up stringer beads thoroughly to prepare for a cap pass.

❑ 27. Use a drag technique to lay stringer beads for the cap.

Note: The total height of the cap pass should not exceed 1/8″ and the sequence has to be followed carefully to accomplish this.

Figure 5



Front view

❑ 28. Clean and inspect cap pass.

❑ 29. Have your instructor check your work.

❑ 30. Turn off machine.

❑ 31. Bend test as specified and save practice workpieces for backgouging assignment in Unit 4.

❑ 32. Check in tools and materials and clean area, or prepare for next job sheet as directed by your instructor.

Evaluator's Comments: _____

_____

_____

Objective 11

Job Sheet 1—Build a Pad On Mild Steel With a Hardfacing Electrode

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• First bead quality	_____
• Second bead quality	_____
• Final bead quality	_____

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- SMAW machine with accessories
- Personal safety clothing and equipment
- Pliers
- Chipping hammer and wire brush
- Mild steel plate as selected by instructor
- Ventilation exhaust equipment for safe hardfacing
- Welding helmet and safety glasses

Specifications

1. Plate and weld symbol

   Figure 1

2. Filler metal: 1/8″ hardfacing electrode compatible with mild steel
3. Electrical characteristics: DC+ or AC
4. Position: Flat
5. Direction of welding: Left to right if you're right handed or right to left if you're left handed
6. Cleaning: Chip and wire brush after each bead

7. Testing: Visual

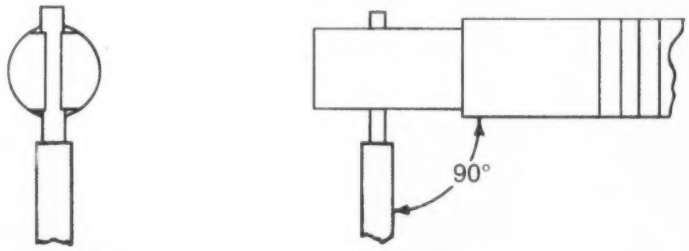
8. Technique: Drag in the same direction rod is angled

Caution: Make sure special hardfacing ventilation is in place and activated before starting this procedure.

Procedure

❑ 1. Place the electrode in the electrode holder as indicated.

Figure 2



Front view Side view

❑ 2. Place selected metal on worktable directly in front of you and attach the ground clamp.

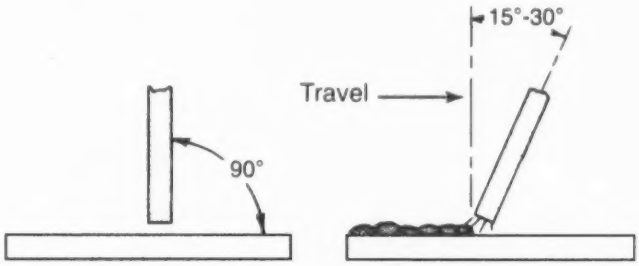
❑ 3. Move electrode down close to the base metal, being careful not to strike an arc, then lower your welding hood to a safe operating position.

❑ 4. Start an arc by moving the electrode across the base metal at an angle about the same as used in striking a match.

❑ 5. Withdraw the electrode just as the arc is struck to form a long arc, and then lower the electrode to minimal arc length.

❑ 6. Make a bead while holding the electrode perpendicular to the plate at an angle of 5° to 30° in the direction of travel while using the drag technique.

Figure 3



Front view Side view

❑ 7. Crater and backfill at the edge of the plates.

❑ 8. Take electrode from holder and place holder on hook.

❑ 9. Secure workpiece with pliers and clean the weld thoroughly with the chipping hammer and wire brush.

❑ 10. Inspect weld for bead width, undercut, spatter, poor fusion, and other defects.

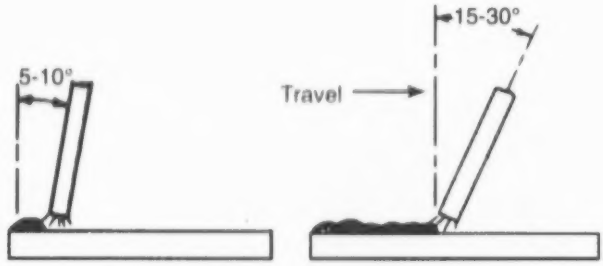
❑ 11. Have your instructor check your work.

❑ 12. Reinstate electrode in holder and position yourself properly over the workpiece.

Caution: If you experience any irritation from electrode fumes, check the exhaust system or check with your instructor.

❑ 13. Start the second bead at the toe of the first bead so that the toe of the second bead laps to the center of the first bead and the electrode is 5° to 10° short of perpendicular.

Figure 4



❑ 14. Continued using the drag technique to complete second bead so that it is the same length as the first bead, then stop, clean, and inspect.

❑ 15. Continue making beads as required to cover the plate by starting at the toe of each preceding bead and keeping the electrode adjusted 5° to 10° short of perpendicular.

❑ 16. Clean each bead thoroughly and inspect for defects.

❑ 17. Complete first layer of beads and inspect the pad.

❑ 18. Shut down equipment, clean up area, and check in tools and materials, or prepare for next job sheet as directed by your instructor.

Evaluator's Comments: _____

_____

_____

341

Objective 12

Job Sheet 2—Prepare and Hardface Simulated Bucket Teeth

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• Workpiece preparation	_____
• First bead quality	_____
• Buildup bead quality	_____
• Finished hardfacing application	_____

Basic Skills

Reading

Critical Thinking

Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- SMAW machine with accessories
- Personal safety clothing and equipment
- Pliers
- Chipping hammer and wire brush
- Mild steel plate as selected by instructor
- Ventilation exhaust equipment for safe hardfacing
- Welding helmet and safety glasses

Specifications

1. Plate and weld symbol

   Figure 1

2. Filler metal: 1/8″ hardfacing electrode compatible with mild steel
3. Electrical characteristics: DC+ or AC
4. Position: Flat
5. Direction of welding: Left to right if you're right handed or right to left if you're left handed

6. Cleaning: Chip and wire brush after each bead

7. Testing: Visual

8. Technique: Drag

Procedure

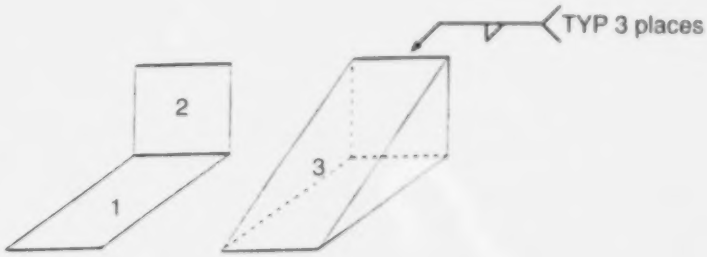
Note: If you have not prepared this workpiece in advance, setup equipment as needed and task weld together with an E7018 electrode the following workpiece to simulate bucket teeth.

❑ 1. Position a 6" by 4" plate to form the base and a 4" by 4" plate perpendicular to form the back of what will become a wedge that you will use for hardfacing.

❑ 2. Hold the pieces with pliers and tack weld the base and back in place.

❑ 3. Hold the third plate so that it completes a wedge shape and tack weld it in place.

Figure 2



❑ 4. Complete a bead along all connecting surfaces so that the three plates are firmly attached and form a wedge shape workpiece that will serve to stimulate bucket teeth as you continue this job sheet.

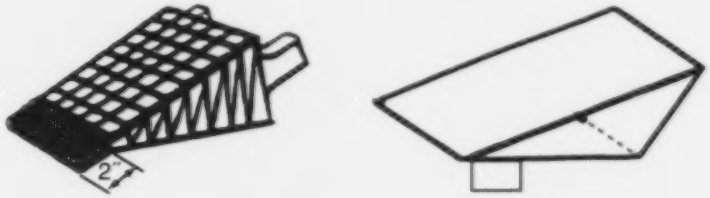
❑ 5. Clean each bead and grind surfaces as needed to prepare a finished workpiece.

❑ 6. Have your instructor check your workpiece; if it is acceptable, continue with the job sheet, and if not acceptable, repeat the preparation process with three new plates.

Caution: Make sure ventilation is in place and activated before starting this procedure, and be sure to keep your head out of the path of the fumes.

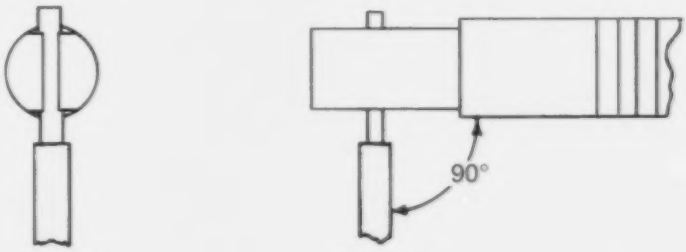
❑ 7. Place the workpiece on one of its flat sides on a worktable so that it resembles the leading edge of bucket teeth, and prop up one edge of the project to create a flat surface to make welding easier.

Figure 3



❑ 8. Place the selected hardfacing electrode into the electrode holder as indicated and made sure the extra exhaust is on and working.

Figure 4



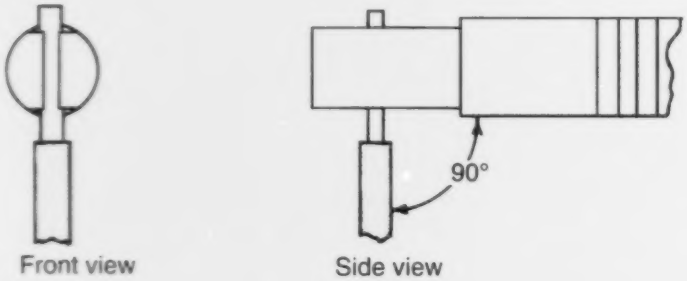
Front view Side view

❑ 9. Position the workpiece on a worktable directly in front of you and attach the ground clamp.

❑ 10. Hold the electrode perpendicular to the plate at an angle of 5° to 30° in the direction of travel, and while using the drag technique, start at the bottom of the leading edge of the workpiece and run a bead parallel to the width of the workpiece.

Note: Placing the beads parallel to the leading edge of bucket teeth simulates buildup for service in rock or slag where hardfacing should run parallel to material flow.

Figure 5



❑ 11. Crater and fill at the edge of the first bead on the workpiece.

❑ 12. Take electrode from holder and place holder on hook.

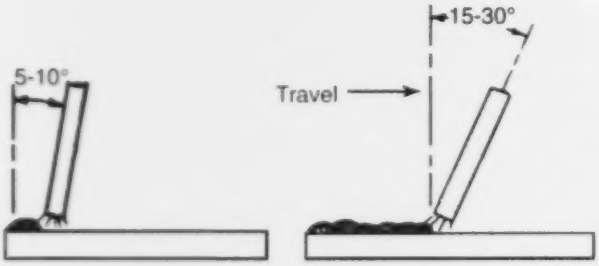
❑ 13. Secure the workpiece with pliers and clean the bead thoroughly with the chipping hammer and wire brush.

❑ 14. Have your instructor check your work.

Caution: If you have experienced any irritation form electrode fumes, report the condition to our instructor now.

❑ 15. Start the second bead at the toe of the first bead so that the toe of the second bead laps to the center of the first bead and the electrode is 5° to 10° short of perpendicular.

Figure 6



❑ 16. Continue using the drag technique to complete the second bead so that it is the same length as the first bead; then stop, clean, inspect, and have your instructor check our work.

❑ 17. Continue running beads parallel to the leading edge of the bucket teeth until they have reach 2" back from the leading edge.

- ❑ 18. Have your instructor check your work.
- ❑ 19. Use pliers to turn the workpiece so that the opposite leading edge is exposed for hardfacing.
- ❑ 20. Begin running beads again, this time run them perpendicular from the leading edge, 2″ back to the workpiece to simulate hardfacing for service in dirt, clay, or sand where beads need to be perpendicular to material flow.

  Note: If bucket teeth will be exposed to both rock and sand or dirt, a waffle pattern should be used for the buildup; that means running beads parallel and then perpendicular or vice versa. See Figure 3.
- ❑ 21. Continue running beads as required to cover the workpiece a distance of 2″ back from the leading edge.
- ❑ 22. Clean all beads and inspect as you complete your work.
- ❑ 23. Have your instructor check your work.
- ❑ 24. Shut down equipment, clean up area, and check in tools and materials, or prepare for next assignment as directed by instructor.

Evaluator's Comments: _____

_____

_____

Objective 12

Job Sheet 1—Gouge a Piece of Mild Steel With the Carbon Arc Cutting—Air Process

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• Proper power and air connections	_____
• Air adjustment and check for moisture	_____
• Proper electrode and air jet angles	_____
• Quality of finished gouging	_____
• Equipment shut down	_____

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Personal arc welding safety clothing and equipment
- Arc welder
- Air carbon arc electrode holder
- Compressed air supply with regulator
- Air hose
- Chipping hammer and wire brush
- Scrap mild steel plate as selected by instructor
- Soapstone and straightedge
- Welding helmet and safety glasses

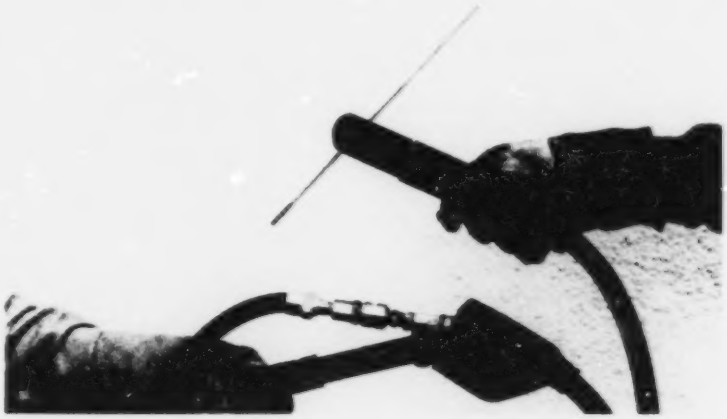
Procedure

❑ 1. Check area to make sure it is free of flammable materials and is well ventilated, and note the location of the nearest fire extinguisher.

❑ 2. Use soapstone and a straightedge to mark a straight line to follow on the steel plate.

❑ 3. Expose air and power connections by pushing back insulated boot on the CAC—A electrode holder.

Figure 1



❑ 4. Attach the welding machine electrode holder to the copper tab on the power cable assembly.

❑ 5. Attach the air hose to the air hose connection and replace the insulated boot over the air connection and the jaws of the welding machine electrode holder.

Figure 2

❑ 6. Attach regulator to compressed air supply and attach hose to regulator.

❑ 7. Adjust regulator to between 60 and 100 psi and spray air on a piece of scrap metal to make sure the air is moisture free.

Note: If there is air in the system, the compressed air tank may need to be drained. If the system works with dryers, check them. If you work with compressed air from a manifold system, you should have no problem with moisture.

❑ 8. Adjust amperage according to electrode diameter.

ELECTRODE SIZE in.	ELECTRODE SIZE mm	COPPER COATED DC TYPES (Reverse Polarity) Amps		AC TYPES Amps	GROOVE WIDTH (Approximate) in.	GROOVE WIDTH (Approximate) mm
5/32	4	90-200		—	3/16	5
3/16	5	150-250		200-250	1/4	6
1/4	6	250-400		300-400	5/16	8
5/16	8	300-500		325-425	7/16	11
3/8	10	350-600		400-550	1/2	13
1/2	13	600-1000		500-600	5/8	16
5/8	16	800-1250		—	3/4	19
3/4	19	1200-1500		—	7/8	22
Semi-Round		Flat Position	Round Position			
3/8	10	200-365	250-500	—	1/2	13
5/8	16	350-1000	600-1200	—	3/4	19
Flats						
3/8	10	400 (max.)		—	1/2	13
5/8	16	500 (max.)		—	3/4	19

❑ 9. Attach ground clamp to workpiece

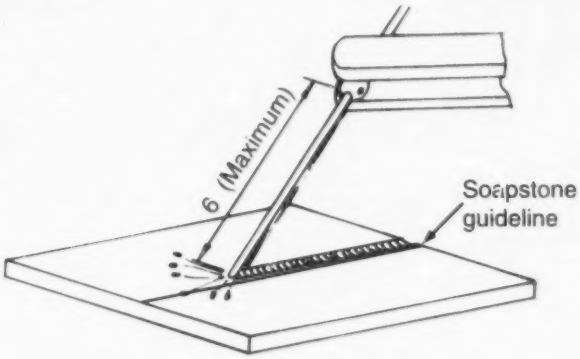
❑ 10. Turn on welding machine.

Caution: Cutting goggles are not safe for gouging. You must wear a welding helmet and ear plugs are also required because gouging is a noisy process.

❑ 11. Place the electrode in the jaws of the CAC—A electrode holder with no more than 6″ of electrode extending in front of the air jets.

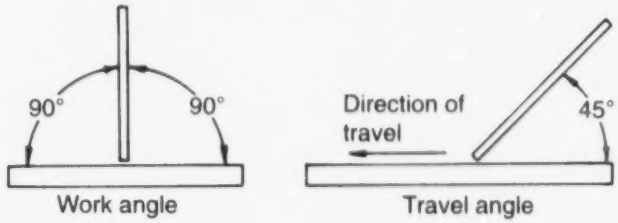
❑ 12. Position air jets under the CAC—A electrode so that air is directed at the point arching to blow away molten metal.

Figure 3



❑ 13. Position the CAC—A electrode angle as indicated.

Figure 4



❑ 14. Turn on air with the air valve on the CAC—A electrode holder.

❑ 15. Start arc and swing the CAC—A electrode in and out of the metal, taking care to maintain the arc and not let it break.

❑ 16. Move the electrode in the direction of the gouge just as the arc first comes out of the base metal and angle of electrode to control gouging depth and contour.

❑ 17. Move the CAC—A electrode in a slight in and out motion the entire length of the gouge.

❑ 18. Finish the gouge, stop, and turn off jet air by using the valve on the electrode holder.

❑ 19. Remove the electrode from the electrode holder and then place the holder in a safe position.

❑ 20. Have your instructor check your work.

❑ 21. Make adjustments, if required, and complete other gouges as directed by your instructor.

❑ 22. Turn off air supply and welding machine.

❑ 23. Remove the CAC—A electrode holder from the air hose and remove the welding machine electrode holder from the insulated boot.

❑ 24. Check in tools and materials and clean the area.

Evaluator's Comments: _____

_____

_____

Objective 13

Job Sheet 2—Backgouge a Piece of Mild Steel Beveled Plate With the Carbon Arc Cutting—Air Process

Name _____ Attempt Number _____

Date _____ Overall Rating _____

Evaluation Criteria	Rating
• Equipment setup and safety	_____
• Proper power and air connections	_____
• Air adjustment and check for moisture	_____
• Proper electrode and air jet angles	_____
• Quality of finished gouging	_____
• Equipment shut down	_____

Basic Skills

Reading Critical Thinking Technology

Instructions

When you are ready to perform this task, ask your instructor to observe the procedure and rate your performance using the evaluation criteria.

Tools, Equipment, and Materials

- Personal arc welding safety clothing and equipment
- Arc welder
- Air carbon arc electrode holder
- Compressed air supply with regulator
- Air hose
- Chipping hammer and wire brush
- Mild steel beveled plate save from Job Sheets24, 26, 27, and 28 in Unit 2 "SMAW Equipment, Applications, and Techniques."
- Soapstone and straightedge
- Welding helmet and safety glasses

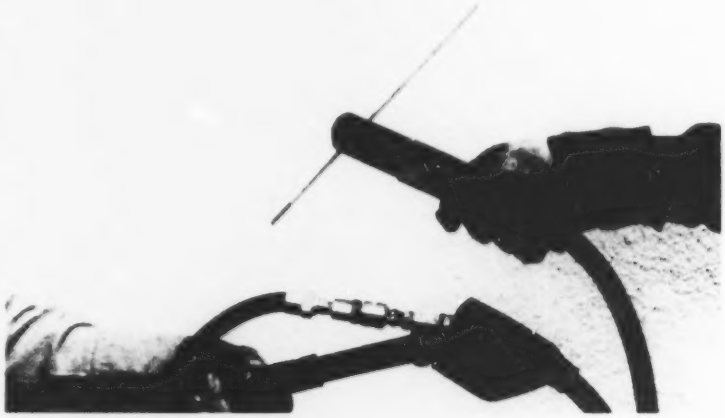
Procedure

❑ 1. Check area to make sure it is free of flammable materials and is well ventilated, and note the location of the nearest fire extinguisher.

❑ 2. Use soapstone and a straightedge to mark a straight line to follow on the back of the beveled plate.

❑ 3. Expose air and power connections by pushing back insulated boot on the CAC—A electrode holder.

Figure 1



❑ 4. Attach the welding machine electrode holder to the copper tab on the power cable assembly.

❑ 5. Attach the air hose to the air hose connection and replace the insulated boot over the air connection and the jaws of the welding machine electrode holder.

Figure 2

❑ 6. Attach regulator to compressed air supply and attach hose to regulator.

❑ 7. Adjust regulator to between 60 and 100 psi and spray air on a piece of scrap metal to make sure the air is moisture free.

Note: If there is air in the system, the compressed air tank may need to be drained. If the system works with dryers, check them. If you work with compressed air from a manifold system, you should have no problem with moisture.

❑ 8. Adjust amperage according to electrode diameter.

ELECTRODE SIZE in.	ELECTRODE SIZE mm	COPPER COATED DC TYPES (Reverse Polarity) Amps		AC TYPES Amps	GROOVE WIDTH (Approximate) in.	GROOVE WIDTH (Approximate) mm
5/32	4	90-200		—	3/16	5
3/16	5	150-250		200-250	1/4	6
1/4	6	250-400		300-400	5/16	8
5/16	8	300-500		325-425	7/16	11
3/8	10	350-600		400-550	1/2	13
1/2	13	600-1000		500-600	5/8	16
5/8	16	800-1250		—	3/4	19
3/4	19	1200-1500		—	7/8	22
Semi-Round		Flat Position	Round Position			
3/8	10	200-365	250-500	—	1/2	13
5/8	16	350-1000	600-1200	—	3/4	19
Flats						
3/8	10	400 (max.)		—	1/2	13
5/8	16	500 (max.)		—	3/4	19

❑ 9. Attach ground clamp to workpiece

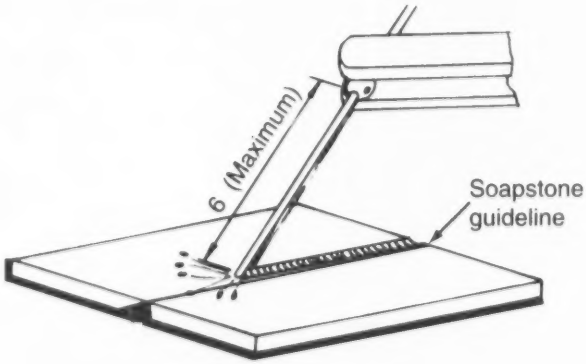
❑ 10. Turn on welding machine.

Caution: Cutting goggles are not safe for gouging. You must wear a welding helmet and ear plugs are also required because gouging is a noisy process.

❑ 11. Place the electrode in the jaws of the CAC—A electrode holder with no more than 6″ of electrode extending in front of the air jets.

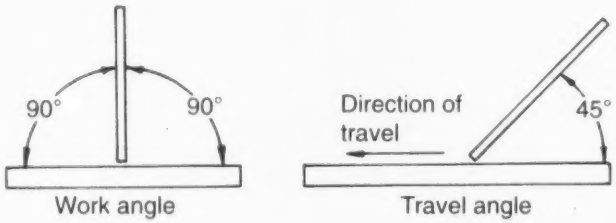
❑ 12. Position air jets under the CAC—A electrode so that air is directed at the point arching to blow away molten metal.

Figure 3



❑ 13. Position the CAC—A electrode angle as indicated.

Figure 4



❑ 14. Turn on air with the air valve on the CAC—A electrode holder.

❑ 15. Start arc and swing the CAC—A electrode in and out of the metal, taking care to maintain the arc and not let it break.

❑ 16. Move the electrode in the direction of the gouge just as the arc first comes out of the base metal and angle of electrode to control gouging depth and contour.

❑ 17. Move the CAC—A electrode in a slight in and out motion the entire length of the gouge.

❑ 18. Finish the gouge, stop, and turn off jet air by using the valve on the electrode holder.

❑ 19. Remove the electrode from the electrode holder and then place the holder in a safe position.

❑ 20. Clean and grind as required to remove any excess material.

❑ 21. Have your instructor check your work to make sure the depth and contour of the gouge will make it suitable for a final full penetration weld so that the total weldmens will be complete..

❑ 22. Make adjustments, if required, and complete other gouges as directed by your instructor.

❑ 23. Turn off air supply and welding machine.

❑ 24. Make adjustments as required and perform other gouges as directed by your instructor.

❑ 25. Remove the CAC—A electrode holder from the air hose and remove the welding machine electrode holder from the insulated boot.

❑ 26. Check in tools and materials and clean the area.

Evaluator's Comments: _____

_____

_____